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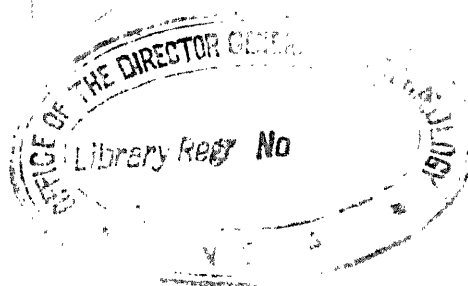
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Board of Scientific Advice for India

for the year 1908-09



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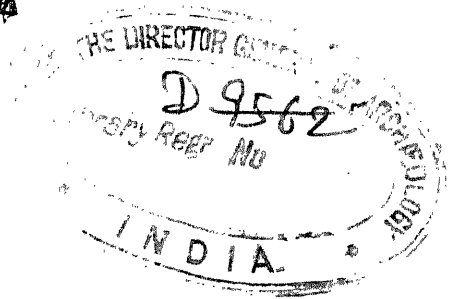
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3. The Director, Geological Survey of India.

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3. The Inspector-General of Agriculture.

Sub-Committee C.—(*Soils and Manures*).

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2. The Director, Geological Survey of India ;
3. Inspector-General of Forests.

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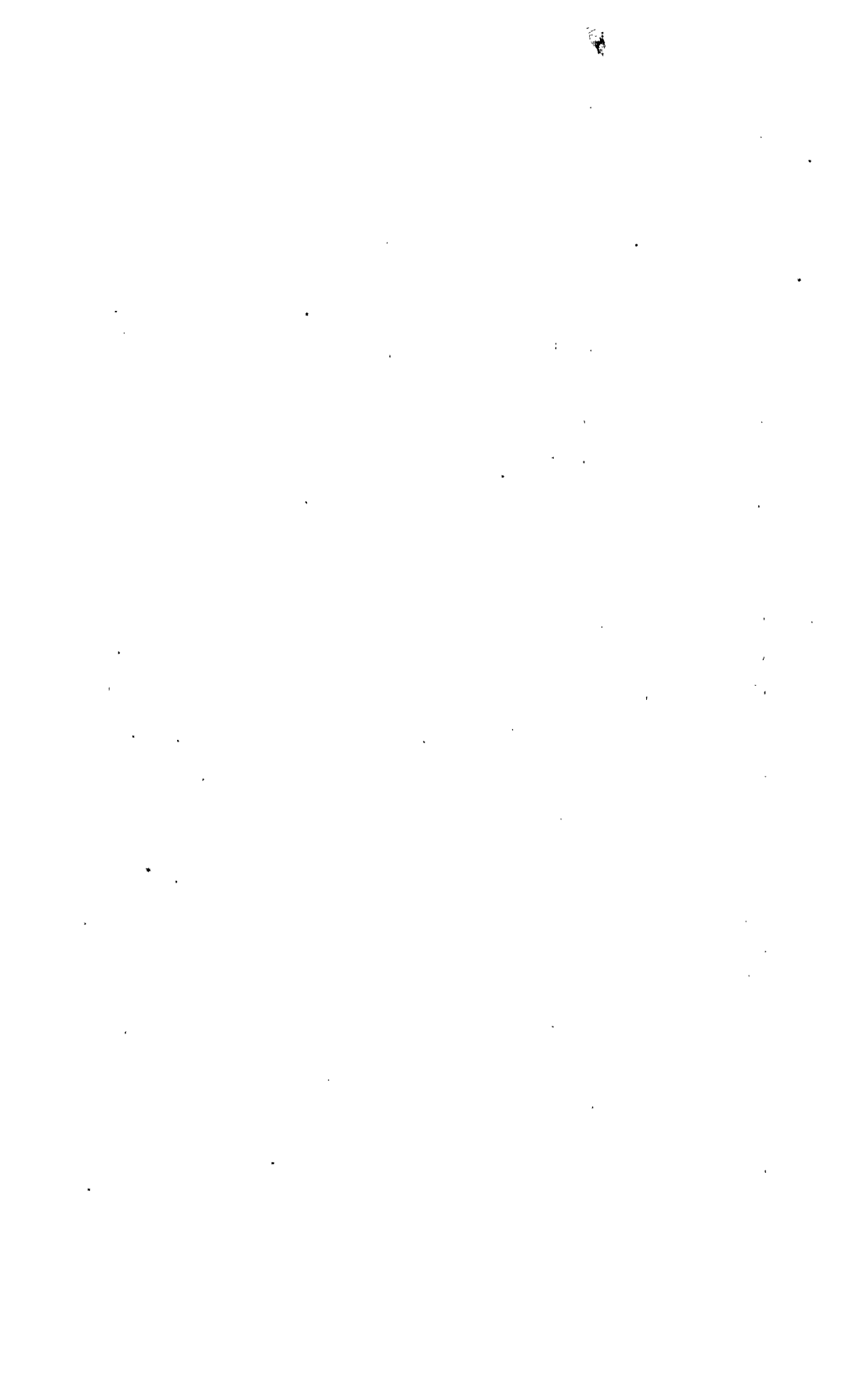
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3. The Superintendent, Industrial Section, Indian Museum ;
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CONTENTS.

Subject.	Contributor.	Page.
I.—Proceedings of the Board.		3
II.—Annual Report.		
INDUSTRIAL AND AGRICULTURAL CHEMISTRY.	I. H. Burkill, M.A., F.L.S., and H. E. Annett, B.Sc., M.S.E., A.C.	9
FOREST CHEMISTRY	Puran Singh, F.C.S.	35
ASTRONOMY (SOLAR PHYSICS)		
METEOROLOGY	G. T. Walker, M.A., Sc.D., F.R.S.	42
TERRESTRIAL MAGNETISM		
GEOLOGY	Sir Thomas H. Holland, K.C.I.E., D.Sc., F.R.S.	59
GEODESY	Colonel S. G. Burrard, R.E., F.R.S.	111
GEOGRAPHY		
BOTANY—		
Botanical Survey	Major A. T. Gage, I.M.S., M.A., B. Sc., M.B., F.L.S.	130
Economic Botany	A. Howard, M.A., A.R.C.S., F.C.S., F.L.S.	146
Mycology	W. McRae, M.A., B.Sc.	152
Forest Botany	R. S. Hole, F.C.H., F.L.S., F.E.S.	153
FORESTRY—		
Sylviculture	R. S. Troup, F.C.H.	163
Forest Products	R. S. Pearson, F.L.S.	169
ZOOLOGY—		
Zoological Survey	N. Annandale, B.A., D.Sc.	172
Agricultural Entomology	H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S.	185
Forest Entomology	E. P. Stebbing, F.L.S., F.Z.S., F.R.G.S., F.E.S.	188
VETERINARY SCIENCE	Col. H. T. Pease, C.I.E., I.C.V.D.	195
III.—Programmes for the year 1909-10		205
IV.—Appendix.		
ECONOMIC INVESTIGATIONS CONDUCTED AT THE IMPERIAL INSTITUTE.	W. R. Dunstan, M.A., LL.D., F.R.S.	229



ANNUAL REPORT FOR 1908-09.

ANNUAL REPORT
OF THE
BOARD OF SCIENTIFIC ADVICE
FOR INDIA

FOR
1908-09.

SUMMARY OF PROCEEDINGS.

Fifteenth Meeting held at Simla on the 10th May 1909.

The Board had under consideration a reference from Government on the question of the disposal of surplus copies of the volumes of the "Fauna of British India." It was resolved to adopt the report of the Sub-Committee to whom the question had been referred and forward it to Government. In the Sub-Committee's report it was recommended that sets of the "Fauna" should be distributed to Provincial Governments for their Agricultural Departments and to deserving Natural History Societies and Museums that require the work but did not possess it; that of the copies remaining after this distribution a certain number ought to be reserved by Government, while the residue should be transferred to one or more of the Agents in India for the sale of Government Publications.

The report of the Sub-Committee on the establishment of scientific libraries in India was then discussed. The attention of the Board had been drawn to the fact that the rapid increase in the number of Scientific Institutions throughout the world was rendering it more difficult to obtain back numbers of the more important scientific periodicals and that unless efforts were made now to secure complete sets of some

of those for India it would be impossible at a later date to establish efficient libraries for the requirements of scientific research in India. The Sub-Committee had issued a circular to all Institutions that seemed likely to include scientific libraries, explaining the object of the enquiry and inviting information regarding the libraries at present existing at the principal centres. After full consideration of the replies received the Sub-Committee submitted a comprehensive report to the Board in which they stated that they were of opinion that it was unnecessary to deal with the question of maintaining College Libraries—in view of the reforms that were in progress in the Indian Universities—or with the Libraries attached to the Scientific Departments of Government. Accordingly the Sub-Committee restricted their recommendations to the maintenance of general reference libraries in each Province of India. They were of opinion that a “first-class” general reference library should be maintained in each of the following Provinces : Bengal, Bombay, Burma, Madras, the Punjab, and the United Provinces. The Sub-Committee gave a list of scientific periodicals that in their opinion should be maintained in all “first-class” libraries. In addition to the “first-class” libraries the Sub-Committee recommended that “second-class” libraries should be maintained in large towns like Ajmere, Cawnpore, Dacca, Jubbulpore, Mandalay, Nagpur, Ootacamund, Quetta, Shillong, Simla, etc. Such libraries would not be sufficient for the requirements of research students but would be of great value to many students who leave the Universities and who otherwise have no opportunities of keeping up their interests in the subjects studied in the Universities. The Sub-Committee gave a list of the scientific periodicals that might be maintained in such “second-class” libraries. A list was also given of the more important scientific journals with prices of complete and short sets and the amounts of annual subscriptions to assist Local Governments and the governing bodies of local institutions in drawing up their estimates of cost. The Sub-Committee drew attention to the imperfect care bestowed on valuable books and explained the importance of preserving sets of reference works complete and in good condition. The Board resolved to adopt the report of the Sub-Committee and forward it to Government with the recommendation that steps should be taken to establish libraries on the lines suggested or to subsidise existing libraries in order that as regards scientific periodicals they might be brought up to the standard suggested in the Sub-Committee’s report.

The appendix to the Annual Report of the Board for 1907-08 giving an account of the work performed at the Imperial Institute of London on behalf of the Government of India was considered. The Board were of opinion that the general practice of mentioning the names of investigators and the authors of reports referred should be adopted in future reports on the work done at the Imperial Institute on behalf of the Government of India.

The Programmes of the various Scientific Departments of Government were discussed and approved with the exception of the Programmes of the Reporter on Economic Products to the Government of India, of the Forest Department, and of the Agricultural Department which were referred to Sub-Committees for revision and re-submission. It was suggested as an addition to the Programme of the Survey Department that arrangements should be made to run a series of levels in suitable places across the foot hills of the Himalayas; that bench-marks should be carefully constructed and preserved in order to determine at some future date the amount of any rise in progress due to earth movements. The Board were of opinion that the exact lines of levels might be settled by consultation between the Surveyor-General and the Director of the Geological Survey, but the Board suggested the following lines might be taken up as soon as convenient :—

- (1) Siliguri to Tindharia; (2) Bareilly to Naini Tal Brewery;
- (3) Najibabad to Lansdowne; (4) Umballa to Solon; (5) Pathankot to Dharmkot.

The remarks of the Advisory Committee of the Royal Society of London on the work of the various Scientific Departments were referred to appropriate Sub-Committees and the Heads of Departments concerned for consideration and submission of reports to the Board.

Sixteenth Meeting held at Simla on the 17th May 1909.

The Board at this meeting read the Report of the Director of the Geological Survey on the criticisms of the Advisory Committee of the Royal Society regarding the work of his Department. On consideration of the report the Board were satisfied that the main energies of the Geological Survey Department were devoted to the preparation of the general geological map of India, that satisfactory progress had been made in recent years, and that it was premature to call for a progress report of the kind recommended by the Advisory Committee.

The Programmes of work for 1909-10 of the Reporter on Economic Products to the Government of India and of the Forest Department, which had been referred to a Sub-Committee at the previous meeting for revision, were resubmitted with alterations and thereupon accepted by the Board.

The Report of the Sub-Committee appointed to consider the criticisms of the Advisory Committee of the Royal Society on the work of the Civil Veterinary Department was also accepted as a satisfactory reply to the remarks of the Advisory Committee on the work of that Department.

Seventeenth Meeting held at Calcutta on 7th January 1910.

The Board read and recorded a letter from the Government of India on the reorganisation of the Botanical Survey and of the Department of Economic Products in which the postponement for the present of the proposals submitted by the Board with regard to those two Departments was explained.

The revised report of Sub-Committee C. on the remarks of the Advisory Committee of the Royal Society concerning the work of the Agricultural Department and the programme of the same department for 1909-10 was considered. The questions discussed in the Sub-Committee's report comprised the work of the Mycologist and the Entomologist; permanent agricultural experiments at Pusa; the manurial requirements of soils; the availability of plant food in soils; the investigation of gases in soils and of the value of Calcium Cyanamide and Nitrates as manures; the investigation of fibre-yielding plants and the co-ordination of the work of the Provincial Agricultural Departments with that of the Central Research Institute at Pusa. It was proposed to omit certain of the subjects for investigation in view of the remarks of the Royal Society's Advisory Committee, but the Sub-Committee of the Board upheld the views of the Agricultural Department with regard to the desirability of experiments with farm-yard manure instead of artificial manure; of pasture experiments and continued investigation of fibre plants, of study of plant nutrition and of the scheme of work of the Mycologist and the Entomologist. The Board resolved to accept the report of the Sub-Committee and to accept the programme of the Agricultural Department as submitted.

The Board again considered the question of whether the names of investigators and the authors of reports referred to should be given in reports on the work done at the Imperial Institute on behalf of the Government of India and while it was held that the names of those who had taken part in enquiries were not required for publication, it was considered important that in scientific and commercial enquiries the departments interested should be acquainted with the names of the experts consulted.

The Draft Annual Report of the Board for 1908-09 was discussed, and after several emendations of and additions to certain of the sections of the report was accepted for submission to Government in due course.

INDUSTRIAL AND AGRICULTURAL CHEMISTRY.

BY

I. H. BURKILL, M.A., F.L.S.,

AND

H. E. ANNETT, B.Sc., M.S.E.A.C.

This report is a review of a year's chemical work done in connection with industries and agriculture in India or on Indian material. We shall endeavour to indicate in it the relation of that work to India's commercial progress. It will be found to record a considerable amount of analytical work: but only a little work on improvement of processes. India's industries are mainly in the copying stage; and the work to hand is therefore the search for material for manufactures to work on. For the purpose of the report the following classification has been adopted:—

- i. Analytical methods.
- ii. Fuel.
- iii. Industries based on mineral production.
- iv. Chemistry and physics of soils and water; manuring.
- v. Analysis of organic raw products and manufacturing processes connected with them—
 1. Gums, resins and rubber.
 2. Oils.
 3. Dyes and dyeing, paints and pigments.
 4. Tans and tanning, glue, size, etc.
 5. Fibres, cordage and fabrics.
 6. Paper and pasteboard.
 7. Building materials.
 8. Flours, sugars, starch, etc.
 9. Accessories to human food.
 10. Spirits.
 11. Drugs.
 12. Cattle foods.
 13. Organic manures.

A bibliography will be found on pp. 30-35. We have been favoured by notes from several chemists in India, and have particularly to thank Dr. R. L. Jenks for the information given under Section v, sub-head 10.

There are but few chemists privately entertained in India: these are attached to sugar works, oil mills, paint works and chemical works. No publications by any of them have come to our notice: what has been done has emanated almost entirely from the official laboratories of the Geological Survey, Imperial Agricultural Department and some of the Provincial Agricultural Departments, Imperial Forest Research Institute, Industrial Section of the Indian Museum, the Cinchona Department Sikkim, and also from the subsidised laboratories of the Behar Planters Association and Indian Tea Association: lastly a small amount of the work done by the Chemical Examiners to the various Provincial Governments and by the Municipal and Customs Analysts is industrial, but is meagrely reported. Enquiry leads to the conclusion that the Chemical Examiners would give useful information on the industrial work were it not that the limit fixed to their annual reports does not allow them to set out more than their administration and their medico-legal results. It seems a pity that these officers and also the Municipal Chemists should not have space to report on the commercial analyses that they perform.

§ i. **Analytical methods.**—Every chemist well knows how rarely it happens in India that a laboratory attains a temperature in any degree approximate to that of laboratories in Europe. Instruments in Europe are calibrated for a temperature of 15° or 20° C and tables are constructed giving the percentage composition of sulphuric acid, etc., of different specific gravities for various temperatures but specially worked out for 15° or 20° C. These temperatures are much below the mean temperature in Indian laboratories and Professor Brühl proposes the adoption as a standard of a temperature of 30° for India. The Asiatic Society of Bengal, before which he laid his proposals, has appointed a committee to collect evidence and opinions, with Mr. D. Hooper as its Secretary. If the laboratories of India agree on a suitable temperature, tables can be forthwith prepared.

Work on analytical methods in regard to Indigo and Ganja will be reported further on.

§ ii. **Fuel.**—Professor E. R. Watson has contributed to the Indian Trade Journal, x, supplement, pp. 2-8, a paper on the "*Calorific and manurial values of Indian cowdung commercially considered.*" He does not concern himself with the value of fuel for factories, but for ordinary cooking as done through India. "No fuel," he finds, "can successfully compete with cowdung cake as a cheap fuel for cooking purposes on a small scale. But whereas the market value of cowdung cake as fuel is

only $4\frac{1}{2}$ annas per maund, this same material is worth $11\frac{1}{2}$ annas per maund as manure, and it would most undoubtedly pay the ryot to reserve his cowdung as manure and buy a slightly more expensive material as fuel. Even taking into consideration the manurial value of the ashes of the cowdung, which may be taken as something less than $3\frac{1}{2}$ annas per maund of dung, it would still amply pay the ryot to use cowdung as manure and buy other materials, say, firewood, coal, coke or kerosine oil as fuel." The value of the cowdung as manure in the above statement was calculated by Mr. B. Coventry.

In the course of his work Professor Watson ascertained the heating power of various other fuels, *e.g.*, firewood from *Ceriops Roxburghiana* (the common Calcutta firewood), kerosine oil of various brands, Bengal coal and coke made from it; and his paper is full of statistics of the prices of these in different parts of India.

Professor Dunstan had reported previously on a sample of Indian cowdung fuel (Bulletin, Imperial Institute, 1908, p. 88). He gives an analysis, and—more important—his estimate of the calorific value is confirmatory of Professor Watson's.

§ iii. **Industries based on mineral production.**—Analyses of minerals from various parts of India, have been made by the Geological Survey of India and will be found reported on in the Geological Section below (p. 60). It is not necessary, therefore, to give details here. Further at the Imperial Institute at the request of the Geological Survey examinations of Bauxite have been made. The production of sulphuric acid in India has increased slightly, but no changes in the chemical processes are recorded. No work has been done on the saltpetre industries.

Table salt produced round the coasts of India is frequently analysed

Salt.	for the salt department, but the analyses are not generally published.
-------	--

The position of the glass-making industry in India is improving somewhat: and in connection with it two papers are of interest, one, Mr. Murray Stuart's report on the suitability of sand in the Raj Mahal hills for glass-making and the other, Mr. Plymen's report on the salt deposit of the Lonar lake. A local soap-making industry is worked with the salts of the Lonar Lake, but the local glass-making and dyeing industries have waned.

§ iv. **Chemistry and physics of soil and water; manuring.**—Most of the work on this subject has emanated from the laboratory of the Imperial Agricultural Chemist.

Analyses of soils have been made by Mr. A. A. Meggitt in Bombay and by Dr. Leather of good wheat-producing soils at Raipur, Central Provinces. A large number of alkali soils from the United Provinces have been examined by Dr. Leather and some from the Bombay Presidency by Mr. Meggitt. It is understood that a memoir is in course of preparation on "The alkali lands of the Nira valley" by Dr. H. H. Mann of the Bombay Department of Agriculture.

Soil moisture.

Dr. Leather made numerous determinations of water in the soil at Pusa throughout the dry season, down to a depth of 7 feet. He holds that his figures shew that water moves upwards in the soil from a limited depth only. In any case, the upward movement of water in soils must take place at a much slower rate than has hitherto been taught. Dr. Russell in criticising Leather's conclusions, however, has stated that the results are equally well explained on the supposition that the upward movement takes place at all depths, since the amount of water present in a particular layer depends on the respective rates at which water is gained from below and lost to the upper layers.

Dr. Leather has replied that he adheres to his original conclusion and adds that if the total decrease of water which occurs during a dry period throughout the strata is ascertained, this will be precisely that quantity of water which has evaporated from the surface of the land. Dr. Russell in a further criticism says that he also does not agree with this later statement. Further experiments in the field made during the last cold weather at Pusa strongly support Dr. Leather's conclusions.

A memoir of the Department of Agriculture gives information regarding the amount of water transpired by some of the commonly cultivated crops, when grown in Behar soil. Although some data have been obtained in other countries, there is need for information of this sort in India, as pointed out in the Indian Irrigation Commission Report for 1901-03. In chapter xi the remark appears, "in the course of our investigations we have been struck with the small amount of attention which appears to have been given by the Departments of Agriculture and Public Works to matters connected with the application of water to cultivated crops." The data presented in the memoir should therefore be of interest and value in India.

The experiments which have been carried out by means of potcultures,

are being checked by experiments in the field. The crops experimented on have been maize, rice, juar, murwa or ragi (*Eleusine coracana*), kodo (*Paspalum scrobiculatum*), arhar or tur (*Cajanus indicus*) and guar (*Cyamopsis psoralioides*), wheat, oats, barley, linseed, sarson, peas and gram.

The amount of water transpired by the plant, per unit increase in dry weight, has been found to be considerably influenced by the following factors :—

(1) *Manuring*.—The amount of water transpired per unit increase in dry weight was found to be much less from plants grown in manured than from those grown in unmanured soil. From reasons given by the authors the conclusion may be drawn that not only manure but good tillage, a deep soil and indeed any factor which aids in good development of the crop will tend towards an economy of water.

(2) *The length of period of growth*.—In general, it has been found that those crops which mature rapidly use less water per unit increase of dry weight than those whose growing period is spread over longer intervals of time.

(3) *The nature of the crop*.

(4) *Temperature and humidity*.—Daily records of the atmospheric humidity have been kept. On a wet day the quantity of water transpired decreased to about one-quarter or one-fifth of what it was on fine day. Charts reproduced in the memoir show that with every serious increase in the humidity there is either a check in the direction of the transpiration curve or a dip in it.

In conclusion the author discusses the amount of water which various crops use up and gives figures to shew it.

In the course of some investigations on soil gases and available plant food in soils, which are in progress in the Chemical Section of the Agricultural Research Institute at Pusa, more accurate information was required on the concentration of calcium carbonate and carbonic acid in water than exists in the literature of this subject. Accordingly a series of measurements have been made, and the data, together with the general formula expressive of the concentration, have been published as a memoir.

The conclusion drawn by the authors (Dr. Leather and Mr. J. Sen) from their investigations is that with the aid of a general formula

deduced by the authors, it is possible from say, an analysis of soil gases, to deduce the concentration of the carbonic acid and calcium carbonate which are actually in solution in the soil-water or as gaseous carbon dioxide respectively; in this case it is to be recollected that a part of the carbon dioxide obtained as *gas* from any soil, will have been present in solution in the soil-water prior to its removal, and this part has naturally to be computed.

Mr. F. Fletcher as a result of experiments in the field and by water cultures has concluded that plants excrete from their roots a toxic substance. Dr. Russell, however, criticises his work, and says that with regard to the field experiments, the falling off in yield which Mr. Fletcher ascribes to the excretion of toxic substances by other plants is no proof that toxic substances are excreted and is generally explained as due to lack of water or food.

With reference to the water culture experiments it may be stated here that Mr. Fletcher obtained a "solution of excreta" by growing plants in water culture and then used this solution as a medium for plant growth. He found the medium to be toxic. Dr. Russell says that Mr. Fletcher took no precaution to prevent development of bacteria and that there is no evidence to shew that the toxic substance was excreted by the plant; it might equally well have been a bacterial product. Mr. Fletcher's contention is at present certainly not proven.

Black cotton soils have been shewn by Mr. Annett to contain a black mineral, titaniferous magnetite, to the extent of several per cent. and the deep black colour is partly due to its presence. In consequence of the presence of the magnetite practically the whole of the soil particles are magnetic. Organic carbon, soluble humus and nitrogen determinations shew that the soils are not rich in organic matter. These soils are highly argillaceous. The results are now ready for publication.

On the Ghats around Poona the cultivators burn brushwood and vegetation generally on the surface of land which is being prepared for rice seed-beds. By this means the crop is greatly increased, and to a much greater extent than can be accounted for by the manurial effect of the ash. The effect is probably biological and the subject is being worked at by the Bombay Agricultural Department.

Mr. Bergtheil finds that the provision of plentiful plant food for Indigo tends to depress the production of

Manuring.

indican and states that he does not think that anything is to be gained at present by further manurial experiments of the ordinary sort.

In the report of the Heeleaka Experimental Station, 1905-08, Mr. Hutchinson states that much further observation of effects of manurial treatment will be necessary before any decided opinions can be arrived at as to the absolute value of any particular style of manuring for tea.

The primary object of the experiments at Heeleaka was to ascertain the relative effect of the various manures on the bushes rather than to determine the optimum amounts to employ. The possibility of lowering of quality, as a consequence of increased yield produced by manuring, is a very serious question and one which has not been lost sight of in the Heeleaka experiments.

The following general conclusions have been arrived at :—

(1) Oilcake as a means of renovating old tea on such light soils as that of Heeleaka, is the most economical in use of any manure tried.

(2) Mineral manures, such as superphosphate, sulphate of potash and nitrate of soda can undoubtedly be utilised successfully for the same purpose, although at a higher cost.

(3) Nitrogenous manures such as nitrate of soda and sulphate of ammonia, produce a better effect if used in conjunction with superphosphate, and potash, these latter in their turn being also dependent for their full effect upon the presence of adequate supplies of nitrogen.

(4) Manures, such as oilcake, produce a very much greater effect if applied in annual small doses than if put on to the same total amount at longer intervals.

The sugarcane manurial experiments at Manjri have been continued and the results may be found in the Annual Report of the Bombay Department of Agriculture, 1907-08.

In his Ninth Annual Report the Mysore Agricultural Chemist discusses the necessity for standardising plots carefully before starting manurial experiments and mentions the result of experiments started at Bangalore. Manurial experiments on paddy have been started.

For tea at Heeleaka the relative results of five green manuring crops have been tested during three consecutive seasons (1905-07). The crops used were

Green manuring.

groundnut, dhaincha (*Sesbania cannabina*), *Crotalaria striata*, mati kalai (*Phaseolus Mungo*), and arhar (*Cajanus indicus*). Arhar was found to give by far the best results.

Experiments are in progress in the Mysore State for the purpose of finding out :—

- (a) if the growing of a green manure is desirable,
- (b) what crop gives the best green manure for ragi (*Eleusine coracana*),
- (c) when can this crop be grown to the best advantage.

In Ceylon the results of green manuring experiments on Gangaroowa tea are very instructive and show a great advantage derived. Poor tea elsewhere is being taken in hand to see how far it can be brought into a high state of efficiency by nitrogenous green manuring with the aid of lime phosphates and potash only.

Experiments on all the chief leguminous plants suitable for green manuring, or as cover plants to keep out weeds have been commenced.

The drainage waters from the gauges at Cawnpore and Pusa have been measured and analysed throughout the year.

Drainage waters.

Samples of canal water from Quetta which were examined in the laboratory of the Imperial Agricultural

Irrigating waters.

Chemist were found to be abnormally rich in dissolved salts. Certain samples were found to contain 20,000 parts of dissolved salts per 100,000, the salts being largely sodium chloride and sulphate with smaller amounts of magnesium sulphate.

Normally, however, the amount of dissolved salts in the waters from 6 canals varied from 100 to 2,500 parts per 100,000. Owing to the harmful effect which such waters might have if used for irrigation, the Imperial Agricultural Chemist toured in Baluchistan. As a result of this tour certain recommendations were made to the Irrigation Officer in Baluchistan. In the main the advice given consisted in recommendations that frequent analyses should be made of the water, and that whenever the concentration of the salts is found to have decreased to a sufficient extent the water should be used for irrigation. After rainfall, for instance, it is generally found that the concentration of the salts drops to 150-200 parts per 100,000 and then the water can probably be used for irrigation without harmful effects.

§ v. Analysis of Organic Raw products and Industries connected with them.—Professor Dunstan has reported on the chemistry of Indian

Gums. gums derived from *Acacia Jacquemontii*, *A. Catechu*, *A. Farnesiana*, *A. modesta*, *A. Senegal*, *Anogeissus latifolia*, *Elæodendron glaucum* and *Prunus eburnea* (Bulletin Imperial Institute, 1908, p. 56). Some of these, he says, may rank commercially as gums of the first grade, *viz.*, those of *Prunus eburnea*, *Acacia Jacquemontii* and *Elæodendron glaucum*, while the rest are second grade. Unfortunately the Indian supply is much greater of the second grade gums than of the first grade; and gums owing to the method of collection are likely to arrive in the market mixed.

Mr. Hooper has given an analysis of the roots of *Eremurus Aucherianus* which are made in Persia into a vegetable glue and then moulded into oil bottles (Indian Museum, Annual Report, 1908-09, p. 16).

Mr. Puran Singh has published important work on shellac. He has suggested that instead of washing the lac dye out of powdered lac, the shellac should be dissolved from off the dye and insect-remains by means of wood spirit. The author stated that he is submitting shellac so prepared to manufacturers in order to see if it satisfies their requirements.

Some analyses of lac from various sources by Mr. D. Hooper are published in the Annual Report of the Indian Museum. He has also examined Keri or refuse lac left from the ordinary process of preparation of shellac in order to see what proportion is lost in it. The Keri contained 55 to 72 per cent. of resin. He has also taken chemical constants for the resins of the following plants:—*Dipterocarpus lævis*, *D. alatus*, *D. obtusifolius*, *D. turbinatus*, *D. tuberculatus*, of an unnamed *Dipterocarpus* from Chittagong, of *Shorea robusta*, *S. obtusa*, *Hopea odorata*, *H. parviflora*, *Vateria indica*, *V. malabaricum*, *Canarium strictum*, *C. bengalense*, *C. resiniferum*: and he has also examined the resins of which *Melipona* bees construct their nests—resin not produced by the insects themselves but collected.

The uses of these resins at present are various: they formerly were largely used for torches, but are little used now: they find their way into varnishes, are used for caulking boats, and a little in medicine. But, East Indian dammar from the Malay Islands at present holds a larger market than they.

Mr. Puran Singh's paper on the constituents of Burmese varnish from *Melanorrhæa usitata* has appeared. Its publication was anticipated in

the report for 1907-08, p. 18. The chief constituent he finds to be urushic acid, which is also the chief constituent of Japanese varnish from *Rhus vernicifera*, and he recommends that all the conditions observed by the Japanese worker in lacquer to obtain the best results should be adopted by the Burmese artisan. The original paper should be consulted for these.

Many samples of sealing waxes have been examined by Mr. Hooper during the last few years in the Indian Museum. A good sealing wax should be composed of 55-60 per cent. resins, 30 per cent. vermilion, 15-10 per cent. of loading. Only a few of the waxes examined carry anything approaching this percentage of vermilion. Some were coloured with red lead and some with aniline dyes. Waxes coloured with aniline soon fade.

Endeavours to put rubber on the European market from new sources have resulted in various analyses of Para rubber, Castilloa rubber, and Ceara rubber from Southern India. *Ficus elastica* from Assam and North Malabar have been examined at the Imperial Institute and reported on in the Institute's Bulletin. Several samples of rubber of *Ficus elastica* have been examined in the Indian Museum.

Oils.	Estimations of the oil in oil seeds have been recorded as follows :—
<i>Sterculia foetida</i>	34 % (Meggett).
<i>Sesamum indicum</i> (Til)	47—57 % (do.).
Castor oil (<i>Ricinus communis</i>)	38·5—52 % (do.).
Ground nut (<i>Arachis hypogæa</i>)	46—47 % (do.).
<i>Bombax malabaricum</i> (silk cotton tree)	30·8 % (do.).
<i>Moringa pterygosperma</i>	22·6 & 25·6 % (do.).
<i>Gynandropsis pentaphylla</i>	25 % (Hooper).
<i>Salvadora oleoides</i>	45 % (do.).
<i>Litsæa zeylanica</i>	61 % (do.).
Cotton seed (husked)	34·8 % (Indian Trade Journal).

Mr. Hooper's investigations are part of a comprehensive survey of Indian oils undertaken with a view to the establishing of reliable test-tables for identification. Acid value, saponification value, iodine value, specific gravity and melting point are among the constants determined. The work will probably be followed up by a study of commercial adulteration.

Dr. J. A. Pearse in his "Report of the Health Officer of Calcutta for 1907," records on the authority of the Calcutta Municipal Analyst the

detection of adulterants in ghi and adds that of 344 samples bought in Calcutta as ghi 203 were adulterated and 11 fictitious. Doubtless there were grounds for suspecting fraud in these samples before they were bought and the percentage of sophistication in them does not in any way indicate that so much is done in the trade. In recording the work of Municipal Health Departments fuller details than are now given would be useful. Adulteration of mustard oil and of butter is also recorded both by Dr. Pearse and by Mr. C. T. Bennett.

The Municipal Analyst, Bombay, records adulteration in 8 samples of ghi out of 44 examined.

Mr. Hooper has examined the oil of the livers of four large fish brought into Calcutta by the Experimental Steam Trawler "Golden Crown", viz.; *Trigon microps*—a sting ray, *Pristis perottetii*—the saw fish, *Stegostoma tigrinum* the spotted shark, and *Ramphobates ancylotomus*. He has also examined the oil of the liver of *Platanista gangetica*—the Gangetic Dolphin.

There was no less than 71.6 per cent. of oil in the liver of the sting ray, as a food possibly of value equal to cod-liver oil: and as the liver weighed 89½ pounds, the fish yielded 66 lbs. of oil. Palmitin was found in different quantities in the different fish. "The large quantity of solid fats would render the oils useful for soap manufacture, while the liquid oil separated from the palmitin would be serviceable for leather dressing, lighting and lubricating purposes."

Several publications relating to Indigo have appeared during the past year. Strenuous efforts are now being made by the producers of natural indigo in India to hold their own against the artificial article. The following remarks summarise the contents of the chief papers issued.

Dyes, Chemistry of Indigo.

Messrs. Perkin and Bloxam have shewn that indican, the glucoside of indoxyl, can be readily isolated from the plant by acetone and as indoxyl condenses with isatin to form indirubin Mr. Bloxam based a method for the analysis of indican upon (i) extraction with acetone and (ii) its conversion into indirubin by addition of isatin. Following this up it was next attempted to find out if the isatin in this method could be replaced by certain aldehydes and with success, for the reaction of p-nitro-benzaldehyde with indoxyl to form p-nitro-benzaldehyde-indogenide was shewn to be quantitative, so that the authors say, "it is thus likely that p-nitro-benzaldehyde can be employed as well as isatin for the estimation of indican in the leaf."

Piperonal was also tried but it does not react with indoxyl quite so readily as p-nitro-benzaldehyde does.

They give an account of the hydrolysis of indican by means of acids.

The results of another investigation shew that when pure indican is hydrolysed by its specific enzyme indimulsin, and the indoxyl thus obtained is oxidised with air, considerably less than a quantitative yield of indigotin, admixed or otherwise with indirubin, is thus produced. This is partly explained by the fact that, due to its unstable nature, indoxyl is slowly converted into a product incapable of yielding indigotin on oxidation. This decay of indoxyl is retarded by the addition of a small quantity of ammonia or lime water. Here it may be remarked that addition of ammonia to the indigo vats has given good results in India and that the addition of lime water is an essential feature of the Coventry process.

The authors conclude (Proc. Chem. Soc. Vol. 25, No. 355 (09)) that the best yields of colouring matter were given in their experiments when a small amount of acid was present during the fermentation and the fermented liquid was then oxidised in the presence of a trace of ammonia.

Mr. A. G. Perkin has contributed two papers bearing on indigo, one on "Indoxylic acid" and another on the reduction of indirubin.

A report to the Government of India was issued in 1908 by Mr. Bloxam on the results of work done in India from 1902-04 on indigo in conjunction with Messrs. H. M. Leake and R. S. Finlow. The results of this work were first published in 1905. In the present report Mr. Bloxam states that before being certain of any efficiency of the manufacturing process or of being able to suggest any valid improvement of it, two factors were necessary, (a) an accurate process for the estimation of the finished product, (b) an accurate knowledge of the amount of colour which could be obtained theoretically from the manufacture, *i.e.*, an accurate knowledge of the indigotin content of the green leaf. He considered, contrary to the opinion of others in India, that these points had not already been elucidated.

Hence the work at Leeds has been largely devoted to the evolution of methods for the analysis of indigo and of plant-leaf for indican content.

Mr. Bloxam has evolved methods which he now considers trustworthy. The present report contains all the publications of Mr. Bloxam and his colleagues and of Mr. A. G. Perkin bearing on the indigo question.

Mr. Bloxam puts forward proposals for the future conduct of experimental work on indigo in India.

Dyeing tests with indigo were carried out at Sirseah, attention being paid to the comparative dyeing properties of natural and synthetic indigo. Not very definite results have been obtained; but there are indications that the natural dye "goes further" than the synthetic dye.

Experiments on manufacture at Sirseah were mainly directed to the question of loading the vats: and it is concluded that good quality Java plant should never be loaded more heavily than 80 maunds per 1,000 cubic feet and the loading should be increased as the quality of the plant falls off.

Mr. Bergtheil says that it is no longer worth while trying to improve the efficiency of the process since it is easy to obtain an efficiency by the present methods of 85 per cent. He makes this statement in the belief at variance with Mr. Bloxam that we have a fairly accurate knowledge of the amount of colour obtainable theoretically from the leaf [*vide* statement (b) on the opposite page].

Experiments on filtering seet-water point to the fact that this operation will not be profitable.

An indigo powder-making machine has been tried with success.

The theory is put forward that the production of indican is a phenomenon which accompanies semi-starvation conditions (compare the statement at the top of p. 15 above.)

A series of pot-cultures were carried out to find the effect of plant stimulants on indican production. The experiments were not duplicated; but there were indications that small amounts of copper sulphate stimulated the plant growth, and also the production of indican. This line of work is being continued.

The main hope for the indigo industry lies along the line of trying to produce a plant with a higher indican content than we have at present. Preliminary experiments suggest that this is possible. A botanist trained in the best lines of plant breeding is about to be appointed to the Sirseah staff; and there is reason to hope that good will result to the indigo planting community.

Tephrosia purpurea Pers. is a small woody annual, growing luxuriantly during the monsoon in many waste tracts of the United Provinces. Messrs.

Dye of *Tephrosia*.

G. Clarke and S. C. Banerjee find that its dried leaves yield about 2 per cent. of a crystalline glucoside, which melts and decomposes at 180-185°, and on hydrolysis with dilute sulphuric acid yields quercetrin and dextrose. It appears, therefore, to be identical with osyritrin (A. G. Perkin, Trans. Chem. Soc., 1897, 71, 1134).

Mr. A. G. Perkin has examined the dyeing properties of the flowers of two plants related to the cotton plant.

Other Dyes,

One of these, *Thespesia Lampas*, contains quercetrin in small quantity, the other, *Hibiscus Sabdariffa*, contains at least two colouring matters, one apparently a new body of the flavone group and the other a dye very closely resembling gossypetin.

Wiechowski's paper on Peori Dye—the yellow dye obtained from the urine of cattle fed on mango leaves—is interesting. It is in chief part euxanthin—a magnesium salt of a peculiar acid,—and decomposes with heat into euxanthic acid of dioxy-dibenzo- γ -pyron. Wiechowski has been able to extract with alcohol from mango leaves a pale yellow crystalline substance euxanthogen which, acted on in the bodies of rabbits, is discharged as euxanthic acid and euxanthon. It now rests with the chemists to bring about the action outside the animal's body and to see if it can be brought within commercial means. Until that is effected the paper is of academic interest, as this quaintly derived Indian dye is going out of use.

Mr. Hooper has estimated the amount of tannin in Canaigre (*Rumex hymenosepalus*) and in Chebulic myrobalans. The first estimation was to see if

Tanning,

Canaigre root grown in Dharwar was equal to its parental stock grown in America. It was not: and a sample grown earlier in the United Provinces was similarly inferior.

The work on Myrobalans showed that certain green and brown myrobalans, supplied for testing, had equal tanning value. The attempt to select brightly coloured nuts for the market by handpicking seems to be misguided.

A complaint was made last year of the loading of hides by a composition apparently of barytes and glucose.

Chemical changes involved in heart damage of baled jute, have been investigated by Messrs. Cross and Bevan in collaboration with Mr. R. S. Finlow.

Fibres—Jute,

The salient characteristics of heart damage are entire loss of tensile strength, great diminution in cellulose content and large increase in the

proportion of matter removable from the jute by water and by simple chemical reagents. One of the necessary conditions for heart damage to occur appears to be the presence of an excessive quantity of water. Jute containing nearly 30 per cent. moisture was baled experimentally and exported to London. It was proved not to have suffered damage *en route* and the fibre was sold in the open market as of first quality. In the investigators' laboratories it was shown that the diminution of cellulose may amount to about 25 per cent. of the total quantity present. The bacteriology of heart damage has yet to be investigated.

Chemical investigations and valuation of Agave fibre from Madras and

Other fibres. Sida fibre have been made at the Imperial Institute: and the percentage of cellulose

(along with other data) is reported as follows:—

Cellulose in Agave rigida fibre from Madras . . .	73.0 per cent.
„ „ Agave americana fibre from Madras . . .	77.0 „
„ „ fibre of Furcræa sp. from Madras . . .	72.0 „
„ „ Agave sisalana fibre from Andaman islands . . .	76.6 „
„ „ Manilla hemp fibre from Madras . . .	70.5 „
„ „ Sida rhombifolia fibre from Bengal . . .	75.5 „

The writers of this report are convinced of the incorrectness of the second name above; it should be Agave Vera-Cruz.

Mr. Hooper has ascertained the percentage of cellulose in the

Paper and pasteboard, following:—

Ischæmum angustifolium from Nepal' . . .	40.4 & 40.7 per cent.
„ „ from Gonda . . .	36.6 „
„ „ from Mailani . . .	40.8 „
Phragmites Karka . . .	41 „
Alpinia Allughas, leaves . . .	21.3 „
„ stems . . .	31.7 „
„ prepared fibre . . .	43.2 „

Professor N. S. Rudolph has investigated the Powell process as a means of preserving Indian soft woods

Building materials. and rendering them available for industrial purposes. The results are satisfactory.

Mr. A. Howard and Mrs. G. L. C. Howard have published a brief report on the milling qualities of some

Flours.

Indian wheats. The wheats reported on were submitted to Mr. A. E. Humphries, Past President of the Incorporated National Association of British and Irish Millers, for a report upon their bread-making value and to Dr. J. W. Leather for chemical examination. The order of baking value and of nitrogen content were

found to be practically the same,—a result which supports work done in England. A further report is promised ; and it will not be time to review the whole of the suggestions raised until it is to hand.

Dr. A. Lehmann has given the following figures to show that Ragi (*Eieusine coracana*) is not a food deficient in phosphates:—Rice contains '35 per cent., Ragi '69 per cent. and oatmeal 1'02 per cent.

Sugar has been the subject of considerable attention. In the first

Sugar.

place must be mentioned the work of Mr. G. Clarke and Khan Bahadur S. N.

Hadi on Gur boiling in the United Provinces. Working with several races of sugarcane they find in the native method of Gur boiling an average loss of 15'7 per cent. sucrose. This is 5 per cent. more than Dr. J. W. Leather found when in 1896 he conducted 8 experiments at Cawnpur and Poona. The inversion in the process they find to be the same as Dr. Leather found it. It is desirable, they point out, to devise ways of saving as much as possible of this sucrose even at the expense of the appearance of the Gur.

The paper is full of analyses of many races of sugarcane taken from different places.

Analyses of races of cane grown at the Manjri farm near Poona have been done by Mr. Meggitt.

The amount of sugar yielded per weight of cane has been recorded by Messrs. Parry & Co. from land at Pattambakam and Sholavelly and by the Behar Indigo Planters' Association from their Benipore Factory.

Tamarisk Manna, which is used as a sugar on the Baluchi-Persian Border, has been reported on by Mr. D. Hooper.

Starch is now manufactured in Eastern Bengal from the root of a

Starch.

Curcuma and also in the north-eastern parts of the Central Provinces. An analysis of Curcuma roots from Eastern Bengal has been made by Dr. Leather, who found 75'5 per cent. of starch in the root.

An analysis of plantain meal by Mr.

Plantain meal.

D. Hooper shows a content of 81'3 per cent carbohydrates.

Mr. Hooper has examined a very large number of rices from various parts of India. The richest contains of its

Rice.

dry weight 92'2 per cent. carbohydrates and the poorest 82'2 per cent. Albuminoids varied from 11'4 to 6'1 per cent. and the fats from 3'6 to 0'1 per cent. In milling with European

machinery the outermost layer of the grain is removed as rice polish and in it is lost the greater part of the fat which the grain contains.

Among miscellaneous foods, have been examined Singhara nuts (*Trapa bispinosa*) by Mr. W. H. Harrison, a Burmese sea weed (*Catánella impudica*) by

Other foods.

Mr. Hooper, and also a preparation from castor oil seed after removal of the oil.

Hartwich and du Pasquier find that by means of hydrochloric acid and gold chloride they can precipitate the caffeine which tea leaves contain *in situ*

Food accessories—Tea.

and by this they have been able to demonstrate that caffeine is accumulated chiefly throughout the whole of the mesophyll. They have further quantitatively estimated the caffeine present, and find for instance quite young leaves to hold 9.2 per cent. and older leaves decreasing amounts up to .8 per cent. at maturity. The wood holds less —.06 per cent. in the stem, none in the root. The calyx holds 2.39 per cent. : the cotyledons about 1 per cent. The authors describe the chemical changes in making black tea thus :—

The greater part of the caffeine is set free in the rolling by the splitting of the caffeine-tannin compound present : next in fermentation part of the tannin turns to phobaphene which gives the leaf its bronze-colour and the caffeine diminishes by about 3 per cent. : lastly in roasting a further 14 per cent. of the caffeine is lost, and of the tannin 8 per cent.

The amount of caffeine in various teas is recorded.

Mr. C. M. Hutchinson traces the cheesy flavour that sometimes spoils tea to wood used for the tea boxes, which has undergone changes due to bacterial decomposition.

A brief note on the proportions of tannin and alkaloids in Indian, Ceylon and China teas appears in the *Indian Trade Journal*, xl, No. 133, p. 63.

Dr. A. Lehmann has given in his report the results of analyses of coffee beans from Mysore, Coorg, the Nilgiris, Nardoobatum, Nelliampathy, Costa Rica, Guatemala, Nicaragua and the Wynaad, in all 49 samples, undertaken with a view to finding a chemical method of estimating the quality of coffee. He is constrained to admit that the results do not forward his object, and that at the present time the specific gravity of the bean, as pointed out by him in an earlier report, is the most reliable numerical index that we possess of the quality of coffee.

Coffee.

Mr. A. Rathje has ascertained what fats are present in the areca nut: he found stearic acid 2.25 per cent.,
Areca nut. palmitic acid 3.1 per cent., myristic acid 21.0 per cent., carmic acid 43.65 per cent., capric acid 1.0 per cent. and oleic acid 29.6 per cent.

There is a considerable amount of work on spirits to record. The
Spirits. "corrected Sikes' Tables" prepared by the Central Excise Laboratory, Kasauli, the new Reduction and Blending Tables and the new method of determining obscuration in spirits were submitted to the Custom Houses of Calcutta, Madras and Bombay for examination, and a member of the staff visited each place in order to demonstrate their utility and initiate practical tests of the same. On the receipt by Government of independent reports from these centres, the final proofs and correction of the Tables were carried out, and the newly compiled Technical Excise Manual completed which was begun last year. The value of the Reduction and Blending Tables being recognised, a much larger edition giving, without calculation, the data necessary for any bulk of spirit required to be reduced from any strength between 60 O. P. to 70 U. P. to any lower strength between the same limits has been in course of compilation and revision during the present year.

The requisite data for a report on the alleged increase in alcoholic strength in spirits stored in casks having been obtained a report on the same is now being prepared.

During the past year, country spirits have been examined at the
Potable Spirits. Central Excise Laboratory from the point of view of general quality, apparent defects in odour, flavour, colour or excessive sediment, for the presence of added substances capable of producing certain harmful effects alleged to be associated with use of the liquor or more generally, for harmful additions of any kind. Under the first heading certain Government distilleries regularly send samples for examination as a control of manufacture. Defects in odour, flavour or colour have been traced to impure water used in dilution, to the absorption of foreign substances from storage vessels or more rarely to errors in manufacture. Direct addition of drugs, etc., has proved almost non-occurrent in the samples as received, but means for effecting such addition at the moment of vend, have been definitely detected.

Important instances of the manipulation of country-spirit to represent so-called foreign spirit have also been dealt with.

The water used for diluting strong spirit in bonded warehouses has been under close examination, impregnation with sulphuretted hydrogen gas being a feature of several samples.

On the fermentation side, experimental fermentations have been conducted on samples of 'mahua' sent for examination; distillery washes have been analysed; the composition of 'Marcha' as a fermenting agent investigated; and illicit washes identified for police purposes. The enquiry into the serious contamination of spirit with copper salts, which obtains in certain parts of India, has been further prosecuted and evidence obtained that the cause is to be assigned not to the peculiar type of still employed but rather to certain constituents in the fermentative base (mahua) employed. Various other matters such as the addition of added sugar to toddy, the age at which toddy is to be considered unsuitable for use, and the artificial regeneration of flat beer have also involved experimental work.

With regard to industrial spirit, trials have been promoted of the type of engine most suitable in India for its utilisation as a motive power, and of the influence, if any, of the new denaturant recommended by the Director of this Laboratory for general adoption in India. Matters relating to the use of spirit methylated in the English fashion, and an abnormal case of caoutchoucined spirit have also been dealt with.

Attention has been directed to the composition of country-made Eau-de-Cologne of which many samples submitted have proved to be made with the help of caoutchoucined spirit deprived in part of the legal proportion of caoutchoucine. This is almost invariably found to be the case when no maker's name appears on the bottle. The alcoholic strength of this commodity moreover shows the greatest possible variations between 60 U. P. and 60 O. P.

Mr. Hooper having observed that the cannabinol in Indian hemp, whether in the form of Ganja, Bhang or Charas, decreases with age, has devised a satisfactory method of determining their intoxicating power by taking the iodine value of the alcoholic extracts.

At Kasauli a large number of samples of charas, ganja and bhang have been investigated some for suspected adulteration, others for deterioration (destruction of these drugs is compulsory after a certain period of time unless they can be shown to be still active), and others again for comparative purposes, as being genuine samples specially supplied. Progress has also been made with an improved method of examination, in conjunction with physiological tests.

A number of genuine or alleged adulterated samples of opium have been analysed at the Central Excise Laboratory as also a series of boiled or 'pukka' opiums with interesting results as to the extremely high percentage of morphine present, on occasion, in the latter.

Opium.

The last reports of both Cinchona Departments record forward steps in the chemical selection of stock plants. In the Nilgiris a tree was found some little time ago to carry 9.56 per cent. of Sulphate of Quinine in its bark, and by propagation therefrom the Madras Cinchona Department has now a considerable supply of young plants. In Sikkim there has been accumulated a still larger supply of improved plants (selected hybrid No. 2) with a content of 6 per cent. The average annual yield in Sikkim of Quinine Sulphate had been increased from a previous 2.68 per cent. to 2.90 per cent. in 1907-08: and if only the latter part of the year reported on be considered the average yield was still higher.

Quinine.

Camphor, etc.

Mention was made in last year's report of Mr. Puran Singh's work on lævo-borneol or Ngai-camphor from *Blumea balsamifera*. Since then his report has been published. Ngai-camphor is in demand in the East as a drug: and it is now being ascertained if profit could be derived from its preparation in Burma. On distillation of *Blumea balsamifera* and also of other Blumeas, a volatile oil (under investigation) is obtained, which besides the camphor might be a source of profit.

Experiments have been undertaken by Mr. Kelway Bamber in Ceylon on the manufacture of papain from the papaya, and a preparation made which is more active than the plain evaporated juice.

Mr. Puran Singh's two larger reports on cutch were referred to by him in last year's report, section Forest Chemistry; they were not in the hands of the writers of the section of the report for 1907-08 on Industrial and Agricultural Chemistry, and therefore for completeness, mention is made of them here. Mr. Puran Singh has published three short papers in the

Catechu.

Indian Forester. He points out that the medicinal katha can be prepared from each of the three sub-species of *Acacia*, e.g., *A. Catechu*, *A. catechuoides* and *A. Sundra*, whereas up till now the first only has been used to supply it, the others furnishing the tanning extract, dark catechu or cutch.

A. catechuoides apparently yields the greatest amount of catechu tannin. He advocates the use of wood spirit for the manufacture of the extract.

It will be remembered that a few years ago an export trade was springing up in Red Rangoon beans, when it was discovered that these seeds during digestion produced prussic acid with consequences fatal according to the quantity eaten. Consequently the trade was arrested. Chemical work on the beans was carried out at the Imperial Institute, where a quantity of related work had already been done. The work on *Phaseolus lunatus* has been recorded in a very interesting form by Professor W. R. Dunstan and Dr. T. A. Henry and again together with the kindred work has been summed up by Drs. T. A. Henry and S. J. M. Auld. Glucosides which yield prussic acid on decomposition are apparently not uncommon in the vegetable kingdom where according to Professor Treub (*Annales du jardin botanique de Buitenzorg*, vi, 1907, pp. 79—106) they are not waste matter, but a form of stored food atoxic to the plant containing them, and though protective, doubtfully so primarily. Linseed, bitter cassava, the great millet, *Lotus arabicus*, Para rubber are all economic plants containing them; but they are not present in all parts or by any means at all times in several of the above. One of the results of this work most interesting economically is the observation that there are other races of *Phaseolus lunatus* besides the Red Rangoon bean, free or nearly free from a Cyanogenetic glucoside; and if these cannot be grown with commercial success in India, successful races might yet be evolved. Drs. Henry and Auld in summing up say, "it will be seen that the matter of the production of hydrocyanic acid by plants affects the utilisation of a considerable number of feeding stuffs. In all the well authenticated cases of poisoning by these products except those mentioned by Robertson and Wynne, it appears that they have been consumed in a condition in which the enzyme was capable of acting on the glucoside and liberating hydrocyanic acid. If, however, the fact now recorded regarding the occurrence of certain quantities of Cyanogenetic glucoside in linseed cake prove to be generally

true and if further investigation proves that the generally innocuous character of linseed cake is due to the fact that the Glucosidolytic enzyme originally present in the seeds is rendered inactive in the hot process of expressing the oil, this would seem to offer a simple method of rendering some at least of these materials suitable for use in feeding stuffs." The enzyme which accompanies Phaseolunatin in the beans of *Phaseolus lunatus*, cassava and linseed, is rendered inactive if heated to 60° C.

Mr. A. A. Meggitt has examined fish manure procurable in Poona.

Manures.

Mr. Main has published a partial analysis of manures used at Dharwar.

A saline soil from Mirpurkhas was examined by Mr. Meggitt. It is described as occurring on the site of an old village and was being largely used with beneficial result as a top-dressing for crops. The presence of about 1 per cent. of calcium and potassium nitrates was held by Mr. Meggitt to account for its beneficial effect.

Mr. W. H. Harrison has described the origin, and method of use as a manure, of a manurial earth which is used in the Kistna Delta. It is collected from the sites of old villages. It may be looked upon as an earth rich in Potash and Phosphoric acid, but contains only about 0.1 per cent. of nitrogen. The amount of this earth now available is very limited.

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FOREST CHEMISTRY.

BY

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The following are the principal investigations conducted by the Chemical Department of the Imperial Forest Research Institute during the year under report :—

The investigation into the manufacture of a suitable tannin extract from the highly coloured bark of Mangrove (*Rhizophora mucronata*) which occupied the Forest Chemist for the greater part of the year, was undertaken at the instance of the Government of Burma. The object of the investigation was to work out a commercial process by which the mangrove extract manufactured at the Government Tannin Factory, Rangoon, could be made as similar as possible to Borneo Cutch (or the mangrove tannin extract manufactured in Borneo). The Borneo Cutch yields soft light buff coloured leather and is sold at remunerative prices, while the Rangoon mangrove extract produces harsh leather of a dark brownish colour with a reddish tint. This objectionable colour makes the Rangoon extract quite unacceptable to tanners.

The chief result of this investigation has been the successful decolorization of the mangrove extract on a small scale in the laboratory. A simple process for the decolorization of the extract has been worked out by the Forest Chemist, and so far as this could be done in the laboratory, the conditions for the manufacture of mangrove extract in a marketable form have been determined. It was supposed that the objectionable colour hitherto obtained from mangrove bark was the result of heat during

the concentration of the tannin liquors, but it has been shown that the colour is inherent in the bark. There is no doubt, however, that the colour is somewhat intensified during concentration by the action of slightly soluble tannin and the pectic and resinous substances, which remain suspended in the liquors and which must be separated by clarification before concentration. The new process devised by the Forest Chemist, besides being much cheaper than the sodium meta-bisulphite process recommended some time back by Professor Dunstan, can efficiently decolorise the tannin liquors during the removal of the above mentioned impurities without appreciably diminishing the percentage of useful tannic principles in the finished extract. The method has been tried several times on a laboratory scale under conditions approximating as much as possible to those obtaining in a modern extract factory; and the mangrove extract obtained has been pronounced to be lighter in colour than Borneo Cutch. The extract is moreover soluble in cold water, and has a high strength in tannin (about 80—82 per cent. calculated on dry material). Further it has been shown by comparative small scale tanning trials carried out in the laboratory that the extract prepared by the new process yields soft pliable pale buff coloured leather which has been pronounced by Messrs. Cooper Allen & Co., of Cawnpore, to be decidedly lighter in colour than that tanned with a standard specimen of Borneo Cutch received from the Imperial Institute, London. In addition to the above experiments a series of tanning trials has been made with mixed tanning extracts, and it has been shown that great improvement can be effected in the tanning properties of mangrove bark by mixing it with a small proportion of Jack wood as suggested by Mr. Hamilton, and that the colour imparted to the leather tanned with such a mixed extract or with pure mangrove extract as obtained by the new process is further considerably diminished and rendered more even by finishing off in a bath of myrabolan. The details of all these experiments are given in the Forest Chemist's Report on the Decolorization of Mangrove Extract submitted to the Government of Burma. Further investigation has been postponed till a trial of the process mentioned above is made on a large scale by working the Rangoon factory, from where it is proposed to send samples of the manufactured extracts to different European firms for commercial valuation.

The new process referred to above has also been applied with success

Sál Tannin Extract.

to the decolorization of tannin liquors from the bark of the Sál tree (*Shorea robusta*). A

series of tanning trials similar to those mentioned above have shown that the extract of young Sál bark as manufactured by the new process is completely free from the defects which have hitherto characterised experiments made with Sál bark. The extract of the old Sál bark, however, was found to impart a faint reddish tint to the leather tanned with it. This reddish tint can be successfully removed by mixing the extract with lighter coloured materials such as babul or myrabolan. Thus it ought to be possible to manufacture suitable tannin extracts from both old and young Sál bark, of which abundant quantities are available in Northern India as waste products. Samples of Sál extract will also be manufactured at the Rangoon Factory and sent to Europe for valuation.

About 150 different samples of Forest oil-yielding seeds of about 40 different forest species received from different parts of India through the Imperial Forest Economist have been under examination. The oil value of these seeds has been determined. An analytical examination of both the seeds and the oils obtained from them by pressure is now being made with the object of ascertaining their possible commercial uses.

The final report on the distillation of *Blumea balsamifera* on a large scale could not be completed this year, because it was found that the ordinary form of condenser does not give satisfactory results in this distillation. Various trials have had to be made to so alter the form of the condenser as to suit the special case of the distillation of the Ngai camphor. Finally a suitable form of condenser has been designed, which affording as it does a large surface for the condensation of the products of distillation readily condenses the latter, from which the solid camphor can be easily removed after the distillation has been accomplished. When the distillation was conducted with water with an ordinary tubular or warm condenser, camphor oil only was obtained from which it was found extremely difficult to crystallize out the solid camphor. Even with the present condenser camphor oil with a relatively small proportion of the solid camphor is obtained when the distillation is conducted rapidly or at a high temperature. The conditions of the steam distillation as now carried on in the laboratory are such that most of the camphor vapours from the still are deposited as solid camphor, and only a small proportion is condensed as camphor oil of a yellowish or brownish black colour. Determinations of the specific gravity and specific rotatory power of the thoroughly dried (not sublimed) camphor show

Distillation of *Blumea balsamifera* DC.

that like the refined Ngai camphor of China it consists almost entirely of L.-borneol. It will thus be seen that the conditions of the distillation as now conducted are normal, and do not allow the products resulting from the decomposition of the plant material, to become mixed with the solid camphor as deposited in the condenser. The specific gravity of our camphor is about 1.016 at 27° C., and its specific rotatory power $[\alpha]_{\text{D}}^{28} = -39^{\circ} 10'$. So far the quantity of camphor oil obtained is insufficient for the determination of its composition and possible uses. It is hoped that the Economist and the Chemist will be able to submit a final report on the subject by the middle of next year.

The enquiry into the utilization of some Indian coloured woods for the manufacture of match sticks was undertaken. at the instance of the Imperial Forest Economist, who pointed out that the bleaching of coloured woods, if it could be done by a cheap method, would be of great importance to the match industry in India. Samples of match splints manufactured from 13 Indian coloured woods which Mr. Troup had selected as suitable for the manufacture of match sticks were received from the Economic Branch of the Forest Research Institute. Besides the Japanese process of bleaching match sticks with sulphur dioxide fumes, two other processes were carefully enquired into. These were:—(1) immersion in a bath of chlorine bleaching liquor and subsequent washing with dilute sulphuric acid and water, (2) immersion in a bath of permanganate of potash (a 2 per cent. solution) and subsequent treatment of the splints with a weak sulphurous acid solution. It was shown by a series of comparative bleaching experiments carried out in the laboratory that different woods require different treatment to be satisfactorily bleached. The bleaching process most generally applicable to the 13 different coloured woods referred to above is the chloride of lime process. It was further shown that if perfectly white colour is not required, the simplest and speediest method of bleaching is the permanganate process. The latter is not as widely applicable as the chlorine process, but in cases where it can be applied with success, it should be preferred to the chlorine and sulphur dioxide processes for the reason that it does not in any way injure the structure of the splints. Sulphur fumes as used by the Japanese were found to have a powerful disintegrating action on most of these woods, although in two cases much more satisfactory results were obtained by the Japanese process than by the other two. As a result of the above

experiments a short suggestive Note on the Bleaching of Indian coloured woods was submitted to the President of the Imperial Forest Research Institute. It will be published as an Appendix to Mr. Troup's Memoir on the Match Industry in India.

At the instance of the Conservator of Forests, Western Circle, United Provinces, an enquiry was started towards the close of the year into the clarification of Indian Colophony. It is stated

Clarification of Indian Colophony.

that dark coloured colophony is clarified in France by means of common salt. The dark coloured Indian colophony has been treated with common salt, crystalline alum and various other clarifying and decolorizing agents. So far crystalline alum has yielded the best results, but the Forest Chemist is not yet satisfied that the question of the best method of clarifying Indian colophony has been finally settled, although dark coloured colophony when clarified by means of alum becomes fairly light coloured. Since this question is of great economic importance, the enquiry into it will be continued with a view to lighten the colour of the colophony to the extent desired by consumers of the article.

The exact calorific power of about 80 different Indian woods has been carefully determined with a view to their application as fuel.

Calorific power of some Indian Woods.

Lac collection in India is rather a complex industry. A detailed enquiry is being conducted as to the normal conditions under which lac should be collected and washed for the removal of mechanical impurities and puparial remains. The object of the enquiry is to make the lac industry of India as simple as possible.

The Lac Industry.

Fairly large quantities of crude lac derived from Kusum (*Schleichera trijuga*) and from Palas (*Butea frondosa*) and also a small amount of coagulated (Block) lac from Raipur have been extracted with wood spirit according to the Forest Chemist's new process. It has been

Shellac manufacture and Lac Analysis.

shown by preliminary analyses of the samples of crude lac extracted that the percentage of the finished extract obtained is in general slightly larger than the percentage of pure lac resin contained in the original material. This is of course due to the simultaneous extraction from the crude lac of that portion of lac wax, which is soluble in boiling hot methyl alcohol and also to the insufficient drying of the extracts. The fact that the percentage of the finished extract even when the influence of these

factors is taken into account has never been appreciably smaller than that of the pure resin in the raw material leaves no room for doubt that the new process of shellac manufacture is almost perfect, at least so far as the yield is concerned.

Further a complete analytical examination of the shellacs prepared from the three different qualities of crude lac has been made, and the results compared with those obtained from the analysis of a pure sample of shellac (free from arsenic and rosin) manufactured at Mirzapur. The results are as follows :—

	Moisture and other volatile matter.	Matter insoluble in hot alcohol.	Acid number.	Saponification number.	Ester number.	Iodine absorption (Hubl) after 18 hours' action.
	Per cent.	Per cent.				Per cent.
Shellac from Kusum lac.	2.7	0.7	61.1	234.3	173.2	9.6
Shellac from Palas lac.	3.8	0.8	60.8	235.9	175.1	9.3
Shellac from Block lac.		1.1	63.1	235.0	171.9	8.2
Mirzapur Factory Shellac.	2.0	0.6	64.4	273.3	172.9	8.6

The purity of the shellac prepared by the new process has further been tested by an admirable process of shellac analysis recently proposed by H. Endemann with the following results :—

	SHELLAC PREPARED IN THE LABORATORY FROM			Mirzapur Factory Shellac.
	Kusum.	Palas.	Block.	
Endemann number (or percentage of non-condensable resins).	8.43	7.96	9.16	7.39

According to Endemann a good pure shellac contains only about 8 per cent. of non-condensable resins and a quantity over this indicates either undesirable impurities or some hard resinous matter which detracts from

the quality of shellac. It would thus appear that shellac from block lac contains about 1 per cent. of this undesirable hard resinous matter. An investigation into the nature of this constituent is now in hand with a view to eliminate it from shellac manufactured from block lac.

From all the above results it is concluded that the different Laboratory extracts are all of a nearly uniform quality and character and compare very favourably with the best shellac of the market, but in the case of shellac from coagulated lac, a larger number of experiments is required to be made to substantiate this conclusion. In order to confirm the value of the shellac prepared in the Laboratory as indicated by chemical analysis, a large number of samples have been sent to well known American and British firms dealing in shellac for practical trials.

In connection with the chemical examination of shellac a determination has been made of the analytical constants of absolutely pure lac resin* which have not hitherto been recorded. Acid number, 59.2; Saponification number, 225.5; Ester number, 166.3; Iodine absorption (Hübl) after 18 hours' action, 6.3 per cent. All these figures, notably the Iodine value, are lower than those generally obtained for shellac. This is explained by the absence of lac wax in the pure resin. The determination of the Iodine value of the same sample of lac resin after melting gave a slightly lower figure, thus showing that melting of lac resin besides bringing about other changes tends to increase the amount of that portion of the resin which is only slightly soluble in cold alcohol. This conclusion is confirmed by a comparison of the Iodine figures for the shellac prepared in the Laboratory (which was dried only by a gentle heat) and for the factory shellac manufactured by repeated melting. The same conclusion has further been substantiated by determining the relative solubility of these shellacs in cold alcohol after making due allowance for the amounts of wax contained in each. A full discussion of all the above results will be found in the writer's Chapter on the Chemistry of Lac in Mr. Stebbing's Note on Lac (2nd Revised edition). A short Note on the Analytical Constant of pure Shellac and Lac Resin is also under preparation and will be shortly communicated through the President of the Imperial Forest Research Institute to the Journal of the Society of Chemical Industry.

* The lac resin examined was prepared from crude kusum lac. It was completely freed from all traces of wax and red-colouring matter, and thoroughly dried without melting. The inherent yellow-colouring matter (erythrolaccin), however, was not removed from it.

Reports and Publications.

- PURAN SINGH . . . Note on the Manufacture of Ngai Camphor.
 DO. . . . A Note on the Manufacture of Shellac (The Note also deals with the utilisation of coagulated lac).
 DO. . . . A Chemical Investigation of the Constituents of Burmese Varnish (*Melanorrhæa usitata* sap).
 DO. . . . A Report on the Decolorization of Mangrove bark tannin extract (not printed).
 DO. . . . Supplementary Report on the Decolorization of Sál bark extract (not printed).

ASTRONOMY.

BY

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Solar Physics.—Researches in solar physics are carried on under the direct control of the Government of India at Kodaikanal, the Director being Mr. Michie Smith and the Assistant-Director Mr. J. Evershed. The chief instruments are :—

- (a) A spectroheliograph made by the Cambridge Scientific Instrument Company, the object of which is that of making photographs of the sun using the light emitted by one chemical element only. In this apparatus a stationary image of the sun is made by a 12-inch triple-achromatic lens of 20-foot focus, fed by an 18-inch Foucault siderostat. Close up to the image and somewhat longer than its diameter is the narrow vertical slit of a spectroscope arranged in such a manner that the light which has passed horizontally through the collimating lens shall be deflected through two right angles by two prisms and a mirror, and shall so emerge from the camera lens parallel to its original direction. This light then falls upon another vertical slit which can be adjusted in such a position as to allow light of any

desired wave length to pass through. In the Kodaikanal spectroheliograph the collimating and camera lenses, each of 5-inch aperture and 6-foot focal length, together with the prisms and slits, are attached to a rigid framework, while immediately in contact with the slit last described is a stationary photographic plate within a fixed camera. The rigid framework is capable of motion in a horizontal plane in such a manner that the primary slit may pass uniformly across the image of the sun while the secondary slit will move at an equal rate across the sensitised plate; and as in each position an image will be formed at the second slit by light of the desired wave length and no other light can emerge, the result of the movement upon the plate is a complete image of the sun in monochromatic light. At present the H and K lines of calcium are largely used on account of the convenience afforded by the width of their absorption shading and the fact that the centre of the dark line is frequently 'reversed', *i.e.*, is bright instead of dark, indicating that the calcium vapour is abnormally hot in the higher levels of the solar envelope. A photograph so obtained shows bright clouds—called 'focculi'—of calcium vapour scattered about over the sun and gives a large amount of information that is not otherwise obtainable. Further, by causing the slits to move more slowly the exposure may be lengthened sufficiently to give photographs of the 'prominences' projecting from the sun's margin.

- (b) Two 6-inch refractors, with one of which an Evershed spectroscope has been used since November 1904. These are used for visual examination of the sun and for spectroscopic study of spots and prominences.
- (c) A spectrograph consisting of an 11-inch polar siderostat with a 6-inch Grubb lens of 40-foot focus. This is used with a 4-inch concave grating of 10-foot focus mounted on Rowland's plan, or a parabolic grating collimated to cure astigmatism, or a plane grating with collimator and camera lenses of 8-foot focus. A powerful spectrograph has also been erected in the spectroheliograph room, using a 3-inch plane grating. It is employed in photographing the ultra-violet region in spot spectra and in studies on the line of sight movement of the chromospheric gases. Both spectrographs have been fitted with special

occulting shutters for regulating exposures in spot spectrum work.

- (d) A photoheliograph by Dallmeyer. With this a photograph of the sun in ordinary light is made daily when possible. Originals are sent to Greenwich for the use of the Solar Physics Committee for those days for which photographs are not available from Greenwich or Dehra Dun.
 - (e) An 18-inch silver-on-glass parabolic mirror (the property of the Assistant Director) has been mounted in front of the 12-inch photovisual lens in the spectroheliograph building. It has been found to be very efficient for photographing spectra, particularly in the violet region. The mirror is mounted in a box upon rollers in such a manner that during the operation of the spectroheliograph and associated instruments it may be pushed to one side so as not to obstruct the light incident upon the 12-inch lens. To bring it into use for photographing spot spectra, etc., the mirror and its mounting are run into position in front of the lens, with the centre of the mirror in the axis of the beam of light coming from the heliostat, an operation requiring a few seconds only.
- A pier is under construction near the mirror to carry a powerful spectrograph and other apparatus used for investigating movements in the line of sight in sunspots.
- (f) A new grating by Michelson has been received from the Cambridge Scientific Instrument Company and a considerable amount of experimental work has been done to ascertain the best methods of using it. It has been found that a large proportion of light is concentrated in the higher orders of spectra, so that the grating will be very efficient for photographing spot spectra under high dispersion. The resolution obtained with this grating is larger than that of any of the gratings previously employed.
 - (g) A Littrow spectroheliograph for photographing the sun's disc in $H\alpha$ light has been partly constructed. Completion has been delayed pending the receipt of a suitable collimating lens and grating.

2. Routine work.—In addition to the use of the spectroheliograph and photoheliograph the routine work includes visual examination of sunspots and faculæ, observations of widened and displaced lines in sunspot

spectra and spectroscopic observations of prominences. A monthly article describing the solar activity is contributed to the "Monthly Weather Review," while for more technical purposes bulletins and memoirs of the observatory are issued. Of the former 17 have appeared, while of the latter the first has recently been published.

3. Photographs of spot spectra are now made in which different exposures are given for the spot and for the adjacent photosphere so that equally dense images of both spectra may be obtained: these are then copied and enlarged with a special apparatus so as to bring out clearly the characteristic features of the spot spectrum. Arrangements have also been made by which the slit of the parabolic grating spectroscope can be replaced by a negative lens and enlarged images of sunspots obtained on a scale of about one metre to the sun's diameter.

4. **The solar constant.**—Progress has been made in developing the method for detecting variations in the solar constant by comparisons of the moon and stars, and a small observatory with revolving canvas roof has been erected for facilitating the work. It has been found advantageous to place the convex quartz reflector at a distance of 75 feet from the photographic apparatus: the starlike image of the moon can then be photographed under exactly the same conditions as the real stars used in the comparisons.

5. **Spectroscopic investigations. Comparison of limb and centre of disc.**—A considerable number of plates of the solar spectrum in which the limb and centre of the disc are compared have been measured with a view to determining the cause of the displacements of the lines at the limb discovered by Halm. The displacements are found in general to be proportional to wave length but appear to differ widely in different lines. The subject is one of great importance in solar physics, but it has been considered advisable to defer measuring more plates until new ones of higher dispersion have been secured with the Michelson grating.

A comparison between Kayser's wave-lengths of certain iron lines in the spectrum of the arc and Rowland's wave-lengths of the same lines in the sun has been made for the purpose of estimating pressure in the reversing layer. This has been rendered possible by the publication of Humphreys' and Duffield's tables of the displacements which spectrum lines undergo when the vapours of the elements are subjected to pressure in the arc. The results indicate a pressure in the reversing layer not exceeding one atmosphere. A critical discussion of this and other estimates of pressure in the sun is given in Bulletin No. XVIII of this observatory.

6. **Pressure in sunspots.**—A number of high dispersion plates of selected regions in sunspot spectra were secured early in the year for the purpose of ascertaining whether any pressure effects could be detected in spots by comparison of certain nickel and iron lines which are largely displaced by pressure with other lines which are but little affected. The plates have been measured and reduced and the results published in Memoir No. 1 of this observatory. It is considered that a small pressure effect can be traced and that the pressure in the umbræ of spots is about one-third of an atmosphere less than that in the surrounding faculose region.

7. **Radial motion in spots.**—The plates obtained for the estimation of pressure in spots have revealed a new and important fact concerning the movements taking place within the penumbral areas of spots, and a large amount of work has been done in determining the nature of the movement observed. Preliminary results of a discussion of about 150 plates have been published in Bulletin No. XV of this observatory; it is there shown that the motion in every spot investigated consists of a radial outflow of the gases of the reversing layer parallel to the solar surface, and accelerating from the centre of the umbræ, where the motion is imperceptible, to the outer limits of the penumbræ, where velocities of the order of 2 km. per second are measured in the case of spots having a diameter of about 30".

Recent results have indicated that there is a small component of motion in a direction at right angles to the radial motion, which proves that the gases are moving outwards in curved spirals, equivalent to a relatively slow rotation of the whole spot system. This movement is of the order of 0.3 km. per second at a distance of 15" from the spot centre, and appears to be of opposite sign in the two hemispheres of the sun, the direction being contrary to the clock in the northern hemisphere and with it in the southern, as seen in projection upon the sun's disc.

The motion displacements of the lines H_β and K_β of calcium vapour over spots are found to be in the opposite direction to that of the lines of the gases in the reversing layer. This indicates that the gases of the higher chromosphere, unlike those of the reversing layer, are flowing inwards towards the spot centre.

All of the above results have an important bearing on Hale's discovery of the Zeeman effect in sunspot spectra and it is believed that much new light may be thrown on the whole problem of sunspots by these investigations.

8. The observatory is now co-operating with the "International Union for Solar Research."

9. There is also at Poona, under the Government of Bombay, the Takhtasingji Observatory, where research in solar physics is carried on by Mr. Naegamvala. The chief portions of the equipment are :—

- (a) A Foucault siderostat with an 8-inch image lens for use with a spectroscope which is now being improved in England.
- (b) An equatorial refractor with a Cooke 6-inch triple photovisual lens. This is provided with two 45° objective prisms, and a prominence spectroscope with a Thorpe transmission grating has been constructed locally for attachment to it.
- (c) An equatorial reflector with a 20-inch mirror by Common. A focal plane ultraviolet spectrograph is now in complete adjustment and it is proposed to employ it for stellar spectra.

The twelve 'most widened' lines in sunspot spectra are observed daily and the results forwarded to Sir Norman Lockyer, and a close agreement is maintained with the observations made at South Kensington. The observatory is also co-operating with the International Union for Solar Research, and is observing the region 5,300 to 5,500 for all lines affected in sunspots.

10. **Solar Radiation.**—Of the three Angström pyrheliometers previously in use in Simla one was taken in January 1908 to the Solar Physics Observatory at Kodaikanal for employment there. The operation of these instruments in Simla and Kodaikanal is, however, difficult and intermittent on account of cloud and atmospheric dust.

METEOROLOGY.

BY

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The Upper Air.—The conditions of temperature and humidity in the upper air have during the last ten years formed a subject of experimental enquiry in Europe and for a shorter period in America. The investigation originated in the work of M. Teisserenc de Bort who from his observatory at Trappes, near Paris, began in 1899 to liberate balloons of varnished paper with recording instruments attached, and offered rewards for the return of the instruments when found on descent. These

balloons were sent up in all types of weather, and their records afforded evidence of the air conditions prevailing up to great heights. It had been known for many years from the experiences of balloonists that the true temperature of the air (*i.e.*, of a body exposed to the air and shielded from radiation) decreased from the ground surface upwards, and the average rate of decrease in unsaturated air, observed up to a height of about 8 kilometres by manned balloons, was found to be about $0.6^{\circ}\text{C. per } 100 \text{ m.}$, a rate which agreed with the results of Lord Kelvin's calculations for an atmosphere where convective currents were active. It was shewn by Teisserenc de Bort, however, that this temperature gradient was not continuous when great heights were reached, and that at a certain point, the mean level of which varied at the same geographical position according to the weather from about 10 km. to 13 km., a stratum of air was encountered in which the temperature assumed an almost constant value up to the highest levels reached by his balloons. This condition was unexpected and surprising, and appeared to put a limit at once to that part of the atmosphere in which convective movements can take place, and thus to indicate a probable limit to the layer of air in which those actions proceed which determine the character of weather. The observations of Teisserenc de Bort have in recent years been verified in America, in many parts of Europe, in Africa, and in the sea areas of northern latitudes. The field of investigations has since assumed such proportions that an International Commission has for some years arranged monthly dates for regular ascents from all countries participating, including series of ascents two or three times a year lasting over several consecutive days. Thus in 1907, from the 22nd to the 27th July, balloon or kite ascents were made at seven stations in Great Britain, about twenty-four in other parts of Europe, four in Asia, one in Africa and four in America; while in addition the navies of Germany, Italy and France and a private French yacht took part in the work over the sea areas from Iceland to the south of the Azores. In 1908 a similar series was organised, and for 1909 December has been chosen as the month for the more elaborate work of the year. As a result of the balloon experiments since 1899 it appears :—

- (1) That the region of isothermal conditions has its lower boundary at heights varying from 8 km. to 17 km. or more, and that it may shew considerable variation of level from place to place at the same time over such a comparatively small area as the British Isles.

- (ii) That its temperature lies between -40°C. and -70°C. , but within these limits varies considerably at a given time over comparatively small areas.
- (iii) That the lower limit lies nearer the earth in regions of cyclonic weather than in those of anticyclones, for the same latitude.
- (iv) That the region lies at greater heights near the equator than in higher latitudes and appears to have there a lower temperature.

The phenomenon has been examined mathematically by Gold, who on certain assumptions shews that such a limit to the decrease of temperature is to be expected in an atmosphere such as the earth's, where the heat from the sun, the radiation from the ground and the absorbing properties of the air are taken into account.

2. Investigation has proceeded far enough to shew that important results may be expected from a further knowledge of the isothermal region and the air strata below it; and, with a view to include India in the increasing area over which experiments are being made, the meteorological department began in 1908 to devise instruments and methods, suitable to the climate and within its financial resources, for carrying on aerial work similar in its more general lines to that which is being done elsewhere. A short description of the preliminary part of the work in India was given in the report for last year. Since then the instruments used have been improved in detail to overcome defects noticed in their records, and the methods of liberating the balloons safely in a wind have been simplified. The balloons have to reach heights where there is only a small proportion of the atmosphere left, and consequently are light and very fragile, the more so as rubber—the usual material for such balloons in Europe—has failed to prove serviceable in India, and we have been forced to adopt open non-expanding balloons of guttapercha tissue. It was found in 1908 practically impossible to liberate such a balloon except in a calm, since in a wind it was destroyed in the act of letting out from the hand the 100 feet of cord which had to be used to separate it from the instrument for the purpose of avoiding vibration in the records. To get over this difficulty of damage to the balloon a device has been adopted by which the instrument can be tied up close to the balloon at liberation (the whole being therefore capable of remaining behind a shelter until free of the hand and safe) and after reaching a height of about 50 metres, *i.e.* when clear of all trees, can unwind its long separating cord. The

arrangement consists of a capillary tube containing air and a single drop of strong sulphuric acid, which is exuded after any pre-arranged fall of air pressure and, by corroding and breaking the shorter string connecting the instrument and balloon, allows the longer string to uncoil slowly from a paper bobbin smeared with viscous material. The cost of this arrangement is only a few annas, while it offers the further advantage that the weight carried by the balloon is less than before, for the releasing apparatus, of weight about 10 grams, falls to the ground when release occurs, while the long connecting cord can be made of fine cotton instead of the coarse string which was previously necessary when the whole pull of the balloon had to be taken by it during liberation from the hand. The results obtained in India in 1908 will shortly be published in detail; they shew among other things that the isothermal region was reached in September at a height of from 14 to 16 km, and that temperature there lay between -55°C . and -65°C . These heights are considerably greater than are generally found in Europe but the temperatures are approximately the same.

3. It is considered that the department is now in a position to undertake a useful part in the international work, and accordingly an effort will be made in December next to liberate instruments on all the days appointed by the commission. Further it is hoped that arrangements will be completed for a project to send off an instrument on every second or third day throughout the whole of 1910 with a view especially to the bearing of the records on our knowledge of Indian weather.

4. Electrical Condition of the Atmosphere.—As stated in last year's report an investigation was undertaken in order to find the electrical condition of rain during thunderstorms. The results have now been discussed and presented to the Royal Society in a paper recently published in its transactions. The following is a short resumé of the paper.

5. The apparatus employed was contained in a hut and in the roof of this was an opening through which the rain fell, being caught in a vessel which was carefully insulated. An electrometer attached to this vessel recorded automatically every two minutes the electricity which had entered the vessel with the rain; an automatic raingauge also was employed to register the quantity of water which fell in each interval. During the course of a rainstorm the quantity of water which fell and the charge which it carried was thus recorded every two minutes; and it was found that the rain of thunderstorm is highly electrified, the

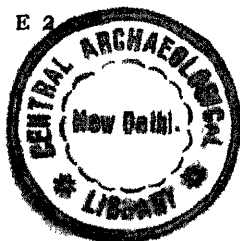
charges being sometimes positive and sometimes negative. As a rule falls of negative and positively charged rain do not rapidly alternate, but the rain during one period of the storm is positively charged and during another negatively charged. One interesting result, which has an important bearing on the theory of the cause of electricity of thunderstorms, is that the heavy rain at the centre of a storm is always positively charged, and that negative electricity is usually associated with light rain.

The charges carried by rain are sometimes very large, on one occasion charges as high as 20 electrostatic units per cubic centimetre of water being measured; in other words, assuming that the rain drops were of a medium size, say, two millimetres in diameter, the potential of each drop would have been 240 volts.

The rain not associated with thunderstorms was found to be not so highly charged, and after the monsoon had well set in it was often impossible to detect any appreciable electricity. It is probable, however, that if apparatus designed to measure very small electrical charges had been employed some charge would have been detected on all rain.

6. In order to determine whether a storm was associated with lightning discharges or not the following well known expedient was employed. A long insulated wire is suspended in the air and one end connected to earth through a coherer similar to those used for wireless telegraphy; each lightning discharge sends out electric waves and these impinging on the insulated wire connected to the coherer cause a record to be made on a strip of paper. Thus every dot on the paper indicates a lightning discharge within a distance of about two miles of the observatory.

7. As no satisfactory explanation of the large generation of electricity in thunderstorms had been given, experiments were made with the object of investigating, as far as possible in the laboratory, the processes in action in thunderstorms, and so determining, if possible, the source of the electricity. After a number of experiments had been made on the mixing of air under different physical conditions with negative results, the electrical effects connected with the breaking of drops of water were examined. Some years ago it had been shown that when drops of pure water fall upon any object and splash, a separation of electricity takes place, the water becoming positively charged and the surrounding air negatively. It was also known that a large amount of breaking up of rain drops by currents of air must take place in a thunderstorm and it therefore appeared desirable to examine the electrical



effects of such a process. Experiments soon showed that there is a considerable separation of electricity when water drops are broken up by passing through the air and it remained to investigate whether the conditions in a thunderstorm are such as to cause results of sufficient magnitude.

8. It would appear that two conditions would be necessary for the manufacture of large charges :—

- (1) there must be a considerable supply of water in the form of drops;
- (2) the drops must be frequently broken up.

Now it is well known that in thunderstorms there are large ascending currents of air, and these produce by condensation large quantities of water; for as the damp air rises it is cooled by expansion and cannot hold all the water that it contained as vapour. It was also known that the small drops of water which form Scotch mist fall only slowly towards the ground, while every size of drop has a definite rate of fall through still air which it cannot exceed: and further that no drop of water having a larger diameter than half a centimetre can fall through air without breaking up into smaller drops. Thus water cannot fall through still air at a greater rate than drops of half a centimetre in diameter; for all smaller drops fall more slowly, and all larger drops quickly break up: this velocity has been found to be about eight metres a second. It follows that if the air is ascending at a velocity of eight metres a second no drops of water can possibly pass down through it to the ground.

9. It is a well established fact that ascending columns of air exceeding 8 metres a second often occur in thunderstorms and near the head of these columns there must be a great accumulation of water in the form of drops which are continually going through the cyclic process of growing from small into large drops which are broken up by the air current. Every time a drop breaks a separation of electricity takes place, the water receiving a positive charge and the air a corresponding amount of negative electricity: the positively charged water remains behind, but the negative electricity is carried away by the air and is rapidly absorbed by the cloud particles, the cloud thus becoming highly charged with negative electricity. At the top of each ascending current there will accordingly be a large separation of electricity which under certain conditions may give rise to all the electrical phenomena connected with thunderstorms.

10. After the publication of the results obtained it was considered desirable that measurements should be continued for another rainy season at least; and on the removal of the Office to the Yarrows, the apparatus was set up in the new compound; since that time, it has been in constant use. Practically the whole precipitation since May 1908 has been investigated, and although the results obtained during the monsoon of 1909 have not been worked out in full detail they appear to corroborate those found during the previous year.

The apparatus for recording the electrical potential gradient in the atmosphere has worked satisfactorily, and the abundant materials which have been collected are now being discussed.

11. Apparatus has been designed and is at present under construction for obtaining an automatic record of the earth-air current of electricity with the object of throwing light on several questions relating to the maintenance of the earth's permanent negative charge.

12. **Vertical pressure differences.**—If certain assumptions are made it is possible from two readings of the barometer taken simultaneously at the top and bottom of a column of air to determine the mean density of the air between the two stations and thence the mean temperature of the column. On these lines the physical changes in the air over Kashmir are being examined, but the facts so far obtained are very complicated. It is likely that a large amount of work will be necessary before final results can be obtained.

13. **The winds of India.**—The importance of a knowledge of the wind system of the country, for practical as well as for theoretical purposes, had been realised quite early in the history of the Department; and Beckley's anemographs have been in use for periods ranging from seven to forty-two years at thirty stations. It had been Sir John Eliot's purpose to discuss the data of seventeen of these, and at the time of his death memoirs dealing with Rangoon, Chittagong, Saugor Island, Calcutta, Allahabad, and Lucknow, had been published, while those of Belgaum and Port Blair were partially written and those of Roorkee, Lahore, Mussoorie, Pachmarhi and Nagpur, were passing through the press. Three of the last have now been published and it is hoped that the discussion of Belgaum and Port Blair may be completed at an early date.

14. **Publications.**—In addition to the Daily Weather Reports published at Simla, Calcutta, Bombay, and Madras, the Monthly Weather

Reviews, the Annual Summary, and various administrative pamphlets the following memoirs have been published departmentally :—

- ELIOT, the late SIR JOHN. A discussion of the anemographic observations recorded at Roorkee from September 1879 to August 1904, at Lahore from January 1890 to December 1904 and at Mussoorie from May to October 1877-1888. (*Mem. Ind. Meteor. Dept., Vol. XVIII, Part IV*).
- ELIOT, the late SIR JOHN. A discussion of the anemographic observations recorded at Pachmarhi from September 1883 to April 1887 and at Nagpur from January 1882 to December 1902. (*Mem. Ind. Meteor. Dept., Vol. XIX, Part I*).
- FIELD, J. H. . . . Kite flights in India and over the neighbouring sea areas during 1907. (*Mem. Ind. Meteor. Dept., Vol. XX, Part VII*).
- PATTERSON, J. . . . The Simla seismograms obtained between June 1905 and November 1908. (*Mem. Ind. Meteor. Dept., Vol. XX, Part III*).
- WALKER, GILBERT T. Correlation in seasonal variation of climate (Introduction). (*Mem. Ind. Meteor. Dept., Vol. XX, Part VI*).

TERRESTRIAL MAGNETISM.

BY

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Magnetic Observatories.—*Bombay (Alibag).*—The Bombay observatory which was formerly maintained by the local Government at Colaba was moved to Alibag in consequence of the introduction of electric trams into the city: it is now directly under the Government of India, the Director being Mr. N. A. F. Moos. The chief instruments are a set of magnetographs of the Watson pattern and a Schulze earth-inductor, in addition to ordinary magnetometers and dip circles. All have given satisfactory results through the year. The results of the sixty years of observations at Colaba are now at the press.

2. *Dehra Dun, Kodaikanal, Barrackpore and Toungoo.*—These observatories were started as base stations in connection with the Magnetic

Survey of India and are all equipped with Watson autographic instruments for declination, horizontal intensity and vertical force. Instead of dip-circles earth-inductors of the Schulze pattern have been set up at each place. Good results have been obtained through the year. At Dehra Dun, however, serious trouble has been experienced owing to heavy rainfall. The magnetograph room had been flooded in 1901 and steps taken to prevent recurrence; in 1905 and 1907 the rainfall was less than the normal and the room remained dry, as it did in 1908 when there was no prolonged period of heavy rainfall although the total amount was in excess. In 1904 and 1906, however, water entered the room.

Experience shows that after three or four days of heavy rain the subsoil becomes waterlogged, water increases in the catchment pit faster than it can be pumped out, and the walls and floor are subjected to a head of 10 feet or more, a pressure which they are ill-calculated to resist. On the 15th August, although pumping with two pumps had been going on day and night for a week, the water had risen to within an inch of the top of the driving clock pillar, and the water level in the catchment pit was 11 feet above the level of the floor of the observatory. It was accordingly deemed advisable to remove the instruments. The horizontal force and declination magnetographs had been working since 1903 with only minor interruptions, and that for vertical force was erected in 1905: the break of record is a great misfortune.

It now appears necessary either to provide a pump capable of raising at least 2,000 gallons an hour direct from the room or the surrounding passage, or to abandon the present observatory and build a new one above ground. Any remedy which aims at excluding water altogether from the present room would involve practical reconstruction, and would be out of the question owing to the inevitable loss of records while the work was being carried on.

3. The mean values of the magnetic elements for 1908 at the observatories are as follows :—

	Declination.	Horizontal force.	Vertical force.	Dip.
Bombay . .	1° 2' 25' E.	36857	15922	23° 21' 1"
Dehra Dun . .	2° 36' 7' E.	33293	31819	43° 42' 2"
Barrackpore . .	1° 5' 7' E.	37031	22038	30° 34' 5"
Kodaikanal . .	0° 45' 4' W.	37434	02324	3° 33' 2"
Toungoo . .	0° 34' 4' E.	38763	16470	23° 1' 2"

4. **Magnetic Survey.**—The general scheme was to execute a preliminary survey of the whole country and a detailed survey of those areas where, owing to local irregularities, further information was required. The preliminary survey was to consist of observations of declination, intensity and dip at about 1,100 stations, and measurements were to be made in successive years at about 22 'repeat' stations in order to effect the elimination of secular variation.

Field work was begun in November 1901 and up to the end of the year 1907-8 1,190 field stations had been occupied and 22 repeat stations established, in addition to 24 stations on the Seistan trade route where declination had been observed: observations had also been repeated at 31 old field stations.

During the field season under report, which extended from the 26th October 1908 to the 3rd May 1909, operations were continued by four detachments. Two were employed in Burma in completing the areas allotted to the preliminary survey; and the two remaining commenced the detailed survey by the examination of several obviously disturbed areas.

5. The party remained in charge of Lieutenant H. J. Couchman, R.E., until the 31st March 1909, when he was relieved by Captain R. H. Thomas, R.E., on return from furlough. The officer in charge with his assistant Lieutenant H. T. Morshead, R.E., who was temporarily posted to the party, visited all the repeat stations, 22 in number, and also re-observed at a number of old field stations. Comparative observations were also taken at the four survey base stations and at Alibag to determine the differences from the survey standard at Dehra Dun.

6. The number of new stations of the preliminary survey occupied was 41, making a total number of 1,255. Of old stations 26 were re-occupied, so that observations have now been repeated at 57 in all.

A new repeat station was established at Port Blair: this had long been considered advisable but it had been found impracticable to spare the necessary time.

In the detailed survey 122 stations were occupied.

7. During the recess season the computations of the field work and the reduction and tabulation of the base station results for 1908 will be completed. The correction of the horizontal force and declination observations for diurnal variation and instrumental differences in declination is in hand, the repeat stations and re-observed field stations being dealt with in the first instance.

8. With regard to the correction for instrumental differences in H. F., the whole question is now under investigation, the main points being—

(a) Whether any correction should be made to the standard on account of change in the moment of inertia.

(b) Whether the discrepancies in different seasons in the differences from the standard can be eliminated by using for

the distribution factor $\log \left(1 - \frac{P}{r^2} - \frac{Q}{r^4}\right)$

instead of $\log \left(1 - \frac{P}{r^2}\right)$.

As regards (a) observations for the moment of inertia have been taken with the standard magnet No. 17 every year, and allowing for the change in weight of inertia bar No. 17 (see Narrative Report for 1904-05) there appears to be a gradual and regular fall in the value, corresponding in 1908 to a correction of -19γ in H. F.

With regard to (b) the expression for the connection between m , H , the deflecting distance r and the angle of deflection u is

$$\frac{H}{m} = \frac{2}{r^3 \sin u} \left(1 + \frac{P}{r^2} + \frac{Q}{r^4} + \dots\right)$$

where P and Q are the distribution constants. The expression $1 - \frac{P}{r^2}$

which is now employed, is obtained on the assumption that $\frac{Q}{r^4}$

is negligible; this however is far from being the case, the correction to the observed value of H. F. varying from 0 to $+60\gamma$ at Dehra Dun with various instruments. The magnitude of the correction moreover is not a constant for any particular instrument, but may vary within considerable limits from time to time; and there is considerable liability to sudden change when there is a sharp drop in the magnetic moment, though the distribution factor now applied may show little or no alteration.

The investigation has necessitated considerable computation but a preliminary reduction of the instrumental differences corrected as above gave promising results, and the investigation will therefore be continued. It may be mentioned that this investigation has considerable bearing on the question of H. F. disturbance corrections owing to the resulting changes in the monthly base lines; it will also affect the secular change values, since various instruments have been used at the repeat stations and re-observed field stations.

An approximate reduction of the H. F. observations at repeat stations and re-observed field stations has also been made. It has indicated that the present number of repeat stations is far too small for the correct appreciation of the annual change, and the present policy of re-observing at a number of old field stations will, as far as time permits, be continued.

9. During the next field season it is intended that the detailed survey shall be continued on the same lines as last year by two detachments.

Two detachments will be employed in re-observing at old field stations particularly in the area lying between Lat. 16° — 19° and Long. 73° — 78° where the secular change in H. F. appears to be particularly abnormal.

The computing section in Dehra Dun will continue the reduction of the preliminary survey, in addition to its normal work of computing and tabulating the base station results.

GEOLOGY.

BY

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CONTENTS.

	PARAS.
INTRODUCTION	1
MINERALOGY—	
Vredenburgite, Sitaparite, Juddite	2
PETROLOGY—	
Singbhum Granophyres, Dalma Trap and Magnesian rocks; Gondite series	3—6
PALÆONTOLOGY—	
Occurrence of <i>Orbitolina</i> , Marine Tertiaries of the Peninsular Coast, Ammonites from the Bagh beds, Molluscan fauna of the Ranikot series, <i>Nummulites Vredenburgi</i> Prever, Liassic and Neocomian of Baluchistan, Tertiary fossils from Upper Burma, Estuarine bed under Calcutta, Lameta fossil fish, Gondwana plants from the Pench Valley	7—20
ECONOMIC ENQUIRIES—	
Alum: Punjab	21
China-clay: Rajmahal hills	23
Chromite: Singbhum, Bengal	24
Copper: Singbhum, Bengal	25
Engineering questions	26
Fire-clay: Rajmahal hills	27
Glass-making sands: Rajmahal	28
Gypsum: Hamirpur district	29
Iron-ore: Chota Nagpur	30
Manganese: Singbhum, Central Provinces. Inspection of Mines in the Central Provinces	31—35
Petroleum: Upper Burma—Taungtha hills, Gwegyo hills, Twinza Reserves; Punjab	36—42
Salt: Rajputana	43
Tin: Mergui and Tavoy	44—53
GEOLOGICAL SURVEYS—	
Baluchistan: Bugti and Marri hills	54—56
Central India and Rajputana: Rutlam, Banswara, Partabgarh, Jaora, Sitamau, Dewas and Indore	57—67
Central Provinces: Chanda	68
Kashmir	69

INTRODUCTION.

1. This summary of results obtained by the officers of the Department during 1908 is designedly brief regarding most of the subjects, as they have been dealt with in separate papers published in the *Records* and *Memoirs*. Where, however, the work done cannot be closed and described for some years, as in the case of the great stretch of previously unsurveyed land in Central India and Rajputana, fuller details are given.

MINERALOGY.

2. The examination of the manganese-ore deposits of India carried out by Mr. L. L. Fermor during the last four years, and the subsequent study at headquarters of the material collected has led to the discovery of several new varieties and species of minerals characterized by the presence of manganese in small or large quantities. Three of these minerals—winchite, blanfordite, and hollandite—have been noticed in previous reports. During the year under review accounts of three more of these minerals—vredenburgite, sitaparite, and juddite—have been published in *Records*, Vol. XXXVII, Part 2.

Vredenburgite is a dark, steel-grey mineral of metallic lustre, with a bronze tint as seen in the sun. It has a hardness of 6·5, and a specific gravity of 4·74 to 4·84. Its most interesting property is its strong magnetism, for, broadly speaking, it is as strongly magnetic as magnetite. It has been found at two localities—Beldongri, Nagpur district, Central Provinces, and Garividi, Vizagapatam district, Madras. Although it is possible to interpret the analyses of this mineral so as to show the presence of Fe_3O_4 in the formula, yet the most simple formula is $3\text{Mn}_3\text{O}_4 \cdot 2\text{Fe}_2\text{O}_3$. The discovery of such a mineral is perhaps disconcerting to the field mineralogist, for it means that when working in a manganese area, it will in future be unwise to assume that a strongly-magnetic, black mineral is magnetite, for it may be a merchantable ore of manganese.

Sitaparite is another bronze-tinted manganese mineral, but its bronze tint is much more pronounced than that of vredenburgite. It is found in the Sitapar manganese-ore deposit in the Chhindwara district. The hardness is about 7, and the specific gravity ranges from 4·93 to 5·09. It is most

easily distinguished from vredenburgite, which it resembles somewhat closely in composition, by its being only feebly magnetic. The one analysis made gave as a result the somewhat complex formula $9\text{Mn}_2\text{O}_3 \cdot 4\text{Fe}_2\text{O}_3 \cdot \text{MnO}_3 \cdot 3\text{CaO}$, assuming that the lime is an essential constituent of the mineral.

Juddite is a variety of amphibole found in association with the manganese-pyroxene, blanfordite, at Kachar-

Juddite.

wahi in the Nagpur district. It is deep crimson as seen in hand-specimens; as seen under the microscope it shows perhaps the most beautiful series of pleochroic colours yet seen in any mineral. The following scheme is probably close to its true pleochroism:—

a = carmine,

b = blue with a lilac tinge, to pale-green with a lilac tinge,

c = orange or pinkish orange.

The mineral is further distinguished from most other varieties of the amphibole group by the position of its optic-axial plane, which is at right angles to the plane of symmetry.

PETROLOGY.

3. Whilst engaged in investigating the copper occurrences of Singbhum during January, February, and March, Singbhum, granophyres.

Mr. Fermor paid considerable attention to the petrology of the Archæan rocks (gneissose granites, Dharwar schists, and intrusive basic igneous rocks) of the district. The most interesting petrological unit in the area is the complex of basic and acid igneous rocks forming Akarsani Hill near Kharsawan, represented by a pink patch on Ball's map of Singbhum and Manbhum, given in *Memoirs*, Vol. XVIII. The basic rocks are probably intrusive in the acid rocks, and of the same age as the other basic dyke-rocks intrusive in the Dharwar phyllites and schists of the area. The acid rocks are hypabyssal in character. They can be best described as *granophyres* and granophyric granite-porphyrries. The most characteristic feature of the rock is the lilac-grey blebs of quartz, by which it can be distinguished, even when it has been rolled out into a schist, the roundish quartz phenocrysts being then represented by drawn-out lilac-grey streaks. A band of this rock has been traced for some 16 miles, to a point as far east as Gomharia,

and there is no doubt, judging from the evidence obtained, that the rock is intrusive into the Dharwars. The rock is, however, so different from the main mass of the gneissose granite of Singhbhum that its intrusive character cannot be taken as evidence that the common gneissose granites are also intrusive, although such is possibly the case.

4. Another interesting petrological unit in Singhbhum is the

Dalma trap.

Dalma trap, forming a range of high hills along the northern border of the district, and separating it from the Lohardaga and Manbhum districts. An examination of it at two or three points showed that it is of complex constitution, having folded up with it bands of Dharwar schists. In composition it consists mainly of varieties of epidiorites, representing, probably, corresponding original varieties of dolerite. In places it is found to contain small quantities of pyrite, chalcopyrite, and in one case pyrrhotite. Considering the epidioritic nature of the trap, it is probable that the sulphides sometimes found in it are of secondary origin, although the metals they contain may have been contained in the original dolerites. It will need a very detailed examination to determine whether the Dalma trap is of contemporaneous formation with the Dharwar schists, or intrusive into them. The balance of evidence points to the latter view, and in this case it seems possible that the Dalma trap and the Akarsani granophyres may be respectively the basic and acid differentiation products of one original magma.

5. Some highly *magnesian rocks* have also been found in association

Magnesian rocks.

with the Singhbhum Dharwars. Such are the serpentines of Suru Pass near Chaibasa, in which chromite is found (which see), and the steatitic rocks of Turamdih, in which magnetite occurs (see under iron).

6. In Chapters XV to XVII of Volume XXXVII of the *Memoirs*, in

**Central Provinces : the
Gondite series.**

the press during 1908, and issued in 1909, a comprehensive account is given of a series of rocks to which Mr. Fermor has given the name *gondite series*, after the aboriginal tribe of Gonds of the Central Provinces. The rocks of this series are supposed to have been formed by the regional metamorphism of manganiferous sediments deposited in Dharwar times. Where the sediments were fairly pure manganese oxides, the only result of metamorphism has been to consolidate them and convert them into crystalline manganese-ores (*primary ores*). But in cases where the chemically deposited manganese-oxide sediments were

mixed with mechanically deposited sediments, such as clay or sand, metamorphism has brought about an interaction between the manganese oxides and the clay or sand, with the production in the former case of spessartite-garnet and in the latter of rhodonite. The rock composed of a mixture of spessartite and quartz is known as *gondite*, and varieties of this rock containing other minerals are designated by qualifying terms; such as rhodonite-gondite, composed of rhodonite, spessartite, and quartz. Owing to the way in which the rocks of this series have been formed they tend to occur as banded masses, the bands representing original layers of different composition.

After these rocks were formed they seem to have been subjected to altering influences, probably waters containing oxygen and carbon dioxide, with the formation of manganese-ores. Such ores may be designated *deep secondary ores*. There are reasons for believing that this alteration of manganese-silicate to manganese-ore took place at the end of the Dharwar period and that therefore, as in the case of the primary ores, the depth to which the deep secondary ores extend bears no genetic relation to the position of the surface of the ground. The rocks and associated manganese-ores of the Central Provinces are found developed typically in the Nagpur-Balaghat area, and also in Jhabua, Narukot, and Gangpur (see page 27). They are to be distinguished from the rocks of the kodurite series (see *Records*, Volume XXXV, page 22), which are of igneous origin.

PALÆONTOLOGY.

7. Mr. E. Vredenburg has recorded an addition to our knowledge regarding the larger foraminifera of India, by his recognition of the important genus *Orbitolina*, which characterises rocks of Lower and Middle Cretaceous age and has not been previously recorded in India. (*Rec. Geol. Surv. Ind.*, XXXVI, p. 314). The Indian specimens were collected by Mr. Hayden between Gurez and Astor, in north-west Kashmir. The Geological Museum also contains specimens collected by Griesbach near Firaiman in Persian Khorasan. In either case the palæontological material is insufficient to establish the exact age of the *Orbitolina* bearing sandstones.

8. In a note published in Volume XXXVI of the *Records* (page 321) Mr. Vredenburg has reviewed the available fossil evidence regarding the age of the Tertiary strata

Marine Tertiaries of the Peninsular Coast.

underlying the coastal laterite that forms an almost continuous belt round the peninsula. Concealed beneath lateritic and alluvial formations, these Tertiary beds have yielded fossils at very few points along the vast extent of their outcrop. The only instances recorded up to the present are the marine fossils discovered by Mr. P. N. Bose in Mourbhanj, the fossil wood of the Cuddalore sandstones, the marine fossils of the "Orbiculina beds" of Quilon, and an extraordinarily rich marine fauna discovered between depths of 115 and 145 metres during the sinking of an artesian well at Karikal. The mollusca from the Orbiculina beds have been partly referred to species occurring in the Gaj beds (Upper Aquitanian to Burdigalian) of North-Western India. The marine beds in Mourbhanj contain an *Ostrea* closely related to an undescribed species from the Upper Gaj.

Out of 101 species so far described by Cossmann ("Faune pliocénique de Karikal", *Journal de Conchyliologie*, Volumes XLVIII, 1900, and LI, 1903) from the Karikal fauna, the richest Tertiary fauna as yet discovered in India, sixteen are identical with fossils from the Miocene of Java. The proportion of recent species in the Karikal fauna is 35 to 40 per cent. This figure agrees with the percentage of recent forms in the Miocene faunas of Java (35 to 50 per cent.) and Burma (30 to 48 per cent.). In the title of his work Cossmann has referred the Karikal fauna to the Pliocene (which, it should be remembered, for the author of the monograph as for many other geologists, includes the Pontian horizon). There seems no doubt that the Karikal beds belong to the same horizon as a portion of the Java and Burma series. Recent researches have tended somewhat to lower the horizon ascribed to the Java beds (Douvillé, *Bull. S. C., F.* Vol. V. (4), p. 435). A much closer palæontological connection than was originally anticipated has also been detected between the Miocene beds of Burma and those of Western India, according to which the Burma series appears to range from Lower to Middle Miocene. This would therefore appear to be the approximate age of the Karikal fauna. It might of course reach into Upper Miocene if one adopts the system of classification that unites the Pontian with the Pliocene. This result agrees with the age indicated by the Mourbhanj fossils and by those from the "Orbiculina beds," and suggests that the Tertiaries in the Coastal System all belong to one period. Yet this palæontological evidence, however satisfactory, is so local as compared with the vast extent of the coastal outcrop that it would be unsafe to generalise from these results.

9. The Bagh beds first discovered by Keatinge in 1857 are of particular interest as a marine representative of the fluviatile Lameta or "Infra-trappean" series. Their total thickness is insignificant, but they have escaped denudation owing to a protective covering of Deccan Trap, and can be followed up the valley of the Narbada from the plains of Gujrat to Barwaha, some 240 miles from the sea-coast. Among the fossils collected by Keatinge, Blackwell, Blanford, and Bose, the echinoids studied by Duncan were found to include several species known from the Cenomanian beds of other lands, such as *Salenia Fraasi*, *Cyphosoma cenomanense*, *Echinobrissus Goybeti*, *Nucleolites similis*, *Hemiaster cenomanensis*, *H. similis* (*Q. J. G. S.*, XXI, page 349, 1865; *Rec. G. S. I.*, XX, page 81, 1887). This palæontological evidence suffices for referring the Bagh beds to the Cenomanian.

The ammonites collected from these same beds by Mr. P. N. Bose during the years 1880 to 1883 form the subject of a paper by Mr. Vredenburg, published in Volume XXXVI of the *Records* (pages 109 to 125). They belong to three species previously undescribed, which Mr. Vredenburg has named *Placenticeras Mintoï*, *Cælopoceras Scindiaë*, and *Cælopoceras Bosei*. Being all three new species, they do not add any further weight to the palæontological evidence furnished by the echinoids, at the same time not clashing with it, since *Placenticeras Mintoï* belongs to a group of forms abundantly represented from the Gault to the Lower Senonian, while the species of *Cælopoceras* so far described are attributed to the Turonian.

The *Placenticeras* specimens are very numerous in Mr. Bose's collection. This ammonite, originally regarded by Feistmantel and Bose as identical with *Pl. tamulicum* from the Trichinopoli beds of South India, has been found to belong to a distinct species, which Mr. Vredenburg has described under the name *Placenticeras Mintoï*.

In comparing the Bagh *Placenticeras* with previously described species, Mr. Vredenburg has been led to classify the members of the genus into four groups distinguished from one another by the gradually increasing complexity of the suture line. The simplest suture is that of *Pl. Warthi* of the Muravatur beds of South India; the group of *Pl. Frittschi* includes a number of species ranging from Gault to Lower Senonian; *Placenticeras syrtale*, with its numerous varieties, characterises the Santonian; the newest group, that of *Pl. placenta* with excessively ramified sutures, characterises the Campanian. *Placenticeras*

Mintoi belongs to the numerous group of forms related to *Pl. Fritschi*, whose geological range is very extensive.

The two other ammonites *Cælopoceras Scindia* and *C. Bosei*, included in Mr. Bose's collections, are each represented by a single fragment. They represent a generic form closely related to *Placenticeras*, for which Mr. Vredenburg proposed the name *Namadoceras*. Subsequently to the publication of his paper, Mr. Vredenburg noticed that his generic diagnosis coincides with that of Hyatt's genus *Cælopoceras* (*Rec.*, XXXVI, p. 239). The American species of *Cælopoceras* occur in the Colorado group which is regarded as Turonian. The European *Ammonites Requièni*, which Mr. Vredenburg regarded as closely allied to the Bagh fossils, and which is likewise referred to *Cælopoceras* by Hyatt, is also Turonian. If the two Bagh ammonites are included in the same genus, the range of *Cælopoceras* must be extended downwards into the Cenomanian.

10. Mr. Vredenburg's translation of Messrs. Cossmann and Pissarro's description of the Molluscan fauna of the Ranikot in Sind, the publication of which had to be postponed owing to the preparation of the illustrations to the stratigraphical introduction, will shortly appear.

The Ranikot strata in Sind are the only authentic representatives of the Lower Eocene so far known in India, and their interest is further increased by their extremely restricted extent. Compared with the enormous development of the Middle Eocene of India, the area occupied by these Lower Eocene beds is quite insignificant, more so even than would appear from the original maps published by Blanford and Fedden: the area as first defined has been considerably reduced in consequence of the withdrawal of the "Meting shales" which were originally incorporated in the Ranikot, but which the palæontological and stratigraphical researches of Mr. Vredenburg have shown to be separated from the Ranikot by an unconformity, and connected with the overlying Laki stage of middle Eocene age. The removal of the Meting shales curtails the outcrop of the Ranikot, as originally mapped, by nearly 200 square miles. This leaves only some 276 square miles as the total area of the Lower Eocene outcrop, of which less than 200 square miles belong to the Upper Ranikot with marine fossils, the Lower Ranikot yielding nothing but plant remains, with the exception of a thin oyster-bed occasionally present at its lowermost limit.

In a previous volume of these *Records* (XXXIV, pp. 85-94 and

172—198), Mr. Vredenburg has indicated the possibility of recognising four principal zones in the Upper Ranikot, the uppermost of which contains the species *Nummulites planulatus*, indicating its approximate correspondence with the "Sables de Cuise." According to the scheme of correlation advocated by Mr. Vredenburg, the underlying zones approximately correspond with the horizon of the London Clay. One of the papers above referred to contains a tabular representation of the distribution of the echinoids within these four zones. In the stratigraphical introduction to Cossmann and Pissarro's description of the molluscan fauna, Mr. Vredenburg has reproduced this list, and has also added a similar table giving the zonal distribution of the Ranikot corals originally described by Duncan (*Pal. Ind., Ser. XIV, Part 2*). In the case of the echinoids and corals, the distribution of the described forms through the successive zones, or at least through the three upper ones, is fairly even, though the species represented in the uppermost zone (zone 4 of Mr. Vredenburg's classification) are somewhat more numerous owing to the greater richness of the collections from this upper horizon. Comparatively scanty collections have been obtained from the three lower zones, whose outcrops are situated in a region rendered somewhat inaccessible from the want of drinking water.

In the case of the Mollusca, the preponderance of material from the uppermost zone is so overwhelming that an attempt to represent the zonal distribution of these fossils in tabular form would be premature. Amongst the materials available for study, by far the greater proportion represents the collections gathered from the uppermost zone by Mr. Vredenburg in 1900 in the neighbourhood of Jhirak, at places very rich in molluscan remains, but which have added nothing of importance to the previously described echinoids and corals. The zone of *Nummulites planulatus* includes no less than 73 out of 100 forms described by Messrs. Cossmann and Pissarro; 53 of these are restricted to the uppermost zone, but this large proportion is due to its preponderating share in the available collections.

The fossils so far described by Messrs. Cossmann and Pissarro include the Cephalopoda, Gastropoda, and Scaphopoda. Out of a total of 100 species, 22 had already been described by d'Archiac and Haime in their classical monograph on the Tertiary fauna of India. The remaining species are all new to science. There are no instances of identity with European fossils, though the relation of certain species to Eocene fossils from Europe or other areas, even as far distant as North America, is sufficiently close for them to be regarded as representative forms.

Certain genera or sub-genera (*Alocospira*, *Aulicina*, *Volutoconus*) absent from the European Tertiaries, exhibit Australasian affinities.

The *Cephalopoda* include the genera *Belosepia*, *Styracothentis*, *Nautilus*. The species *Styracothentis orientalis* Crick, very abundant in the uppermost zone, is particularly interesting as an example of one of the last of the extinct group of the belemnites, intermediate in its characters between the Upper Cretaceous genus *Belemnitella*, and the Eocene genus *Vasseuria*. The species was originally described from a specimen collected on the Oman coast of Arabia, thereby indicating the presence of Lower Eocene beds along the Arabian as well as along the Indian shores of the Arabian Sea.

Amongst the *Gastropoda*, the *Opisthobranchia* are represented by the genera *Tornatellæa*, *Bulla*, *Acera*. Of the various families of the *Prosobranchia*, those most abundantly represented are the *Pleurotomidæ* (10 species), *Volutidæ* (8 species), *Strombidæ* (9 species), *Turritellidæ* (6 species), *Naticidæ* (13 species). The species of *Strombidæ* in particular are represented by numerous specimens. Amongst species that are particularly abundant may be mentioned: *Surcula Voyseyi* d'A. and H. (zone 4), *Volutospina Sykesi* d'A. and H. (all horizons), *Cassidaria Archiaci* C. and P. (zone 4), *Gisortia Murchisoni* d'A. (zones 2 to 4), *Calyptrophorus indicus* C. and P. (principally zone 1), *Rimella Prestwichi* d'A. and H. (principally zone 4), *Terebellum distortum* d'A. and H. (zones 3 and 4), *Terebellum plicatum* d'A. and H. (zones 3 and 4), *Chenopus dimorphospira* C. and P. (zones 3 and 4), *Rhinoclavis subnuda* d'A. and H. (zones 2 to 4), *Rhinoclavis angustoma* d'A. and H. (zones 2 to 4), *Turritella angulata* J. de C. Sow. (all horizons), *Mesalia Mecquenemi* C. and P. (zones 2 to 4), *Ampullina sindensis* C. and P. (zones 2 to 4), *Ampullina aulacospira* C. and P. (zones 2 to 4), *Velates Noetlingi* C. and P., closely related to the European fossil *Velates Schmideli* (zones 2 to 4), *Delphinula Cordieri* d'A. (zone 4).

11. In describing an interesting nummulite from the eocene of north-western India under the name *Nummulites* **Nummulites Vredenburgi** Prever, *Douvillei* (*Rec. G. S. I., Vol. XXXIV, pp. 79-95, 1906*) Mr. Vredenburg was unaware that this name was pre-occupied by a species from the Apennines described by Dr. Prever in a monograph which was not then available in the library of the Geological Survey (*Mem. Soc. Pal. Suisse, Vol. XXIX*). Dr. Prever has proposed to substitute the name *Nummulites Vredenburgi* Prever, for the Indian fossil (*Rec. G. S. I., Vol. XXXVI, p. 239.*)

12. Mr. G. H. Tipper has nearly completed an account of the Liassic and Neocomian fossils of Baluchistan. The collections which form the basis of his report were obtained mainly during the field-season 1905-06, while surveying the Native States of Kalat and Las Bela in Baluchistan. But there are also included collections made previously by Mr. Vredenburg in the vicinity of the Takatu, and by Kishen Singh, late Sub-Assistant, from near Kalat. In 1907-08, while on study leave at Cambridge, Mr. Tipper made a preliminary examination of the whole of the material and a direct comparison was made with the chief European fossils. The detailed examination, continued since, so far as other duties have allowed, has given the following results.

The divisions suggested from the study of the deposits in the field have been fully borne out; that is, the Baluchistan Lias may be divided into Lower, Middle and Upper. The character and distribution of these three are roughly as follows:—

Lower Lias.—Crinoidal limestones and shaley beds. Shirinab valley, south of Mastung.

Middle Lias.—Black limestones of the Takatu Oolitic limestones and shales of Sarawan and Northern Jhalawan. Black shales and limestones of southern Jhalawan and Las Bela.

Upper Lias.—Black shales of the Natrani river, Las Bela.

The Lower and Upper Lias are but poorly developed, while the Middle includes almost all the exposures examined in Sarawan, Jhalawan and Las Bela.

The place of the lower and upper divisions is readily established by the fact that they have yielded ammonites closely related to, if not identical with, well-known European forms. Thus the Lower Lias has yielded *Arietites* *sp. aff. bisulcatus*. The presence of this fossil shows that only the lowermost zone is represented. Other fossils are by no means well preserved, and their affinities cannot be made out with satisfaction.

The Upper Lias of the Natrani river yielded a rich collection of ammonites, which, although not very well preserved, are yet good enough for their affinities to be made out. The following species have been recognised:—

Harpoceras *cf. serpentinum*.

Dactylioceras *cf. annulatum*.

Hildoceras *sp.*

Oxynotoceras *sp.*, young form.

These forms are typically Upper Liassic in age. All these ammonites were weathered out and collected from one gentle dip-slope, so that the whole of the Upper Lias in this locality is crowded into a thin band of shale. The only other fossil found associated with these ammonites is a *Spiriferina*, which occurs in large numbers. This graceful ribbed form with a rather high area is distinct from any described form, and is undoubtedly new.

The Middle Lias has yielded a very rich and interesting fauna, in which unfortunately ammonites are very rare, and exact correlation is a matter of difficulty. There are three areas where the Middle Lias is well developed, and, as these areas seem to correspond to differences in fauna, they may be treated separately. The faunistic differences may be more apparent than real and are probably due to hurried collecting. The areas may be designated (1) the Takatu, (2) Sarawan and Northern Jhalawan, (3) the Porali river.

Taking them in order, the Takatu area has yielded a fauna rich in numbers, but poor in species. It includes among the brachiopods *Spiriferina nov. sp.* No less than 989 specimens of this species occur. Although there is a considerable variation among them, yet it is not definite, and the specimens cannot be grouped except as a whole. Specimens of this species are small in size and generally smooth. Those specimens which have passed maturity show faint ribs, and are much stouter in habit than the young and mature forms.

Spiriferina rostrata Schloth. There are several specimens which may be referred to this species.

A single specimen of a peculiar *Spiriferina* occurs. It is extremely broad and very thin. Although very distinct, it is probably a sport and not a new species. Under the designation *Terebratula synophrys* Uhlig, *T. pacheia* Uhlig and *T. synophrys* var. *polyptycha* del Piaz. may also be included. All these forms occur, and are to be considered as variations of the type form. The young of this species is quite smooth.

The occurrence of *Eudesia sp.* in the Lias of Baluchistan must be considered as one of its chief peculiarities, as elsewhere it is not found at a lower horizon than the Inferior Oolite. This genus occurs in considerable numbers not only in the Takatu area, but also to the south. Several specimens closely related to the European form *Rhynchonella tetraëdra* Sow. occur. Of the lamellibranchs, the chief representative is the genus *Pecten*, with two species, the first related to *Pecten (Aequipecten) æquivalvis* Sow., and the second to *Pecten (Entolium) hehlii* d'Orb.

The rich and varied fauna of the Sarawan and Northern Jhalawan area has not been thoroughly worked out yet, but the following are the most interesting points:—

- (1) The presence of the genus *Eudesia*, represented by a species different from that of the Takatu area.
- (2) The occurrence of a very peculiar *Pecten*. This at first sight resembles *P. alatus* von Buch of the Lias of South America, but it differs in several important particulars; the ribs are more numerous, angular, and bear distinct spines, and during part of its life it was fixed by the left valve. This has led to the formation of a distinct angle, the upper part flat or concave and the lower, convex. The appearance of this *Pecten* is so striking that it is used as a charm by the inhabitants of Jhalawan.

Spiriferina di Stefanoi del Piaz found in this locality, is a species with a high triangular area and peculiar ornamentation; according to Dautzenberg it ought to be raised to subgeneric rank. The occurrence of a new genus of echinoids is also of considerable interest. This and the remaining forms will be described in Mr. Tipper's memoir. No ammonites were discovered in this area.

The Porali river area is particularly interesting, not only on account of the splendid preservation and number of the fossils, but also because many of them closely resemble Liassic fossils from Madagascar recently described by Thevenin in the *Annales de Paleontologie, tome III, fasc. III*. Thevenin describes a Middle Lias fauna comprising, among other forms, a new genus of ammonites *Bouleiceras*, *Pecten ambongoensis* and *Spiriferina rostrata* var. *madagascarensis*. These three forms can be matched from the Porali river collection. At the time of collecting three well-preserved fragments of an ammonite were obtained and at once recognised from the peculiarity of the suture as probably new. There is now very little doubt that they belong to the genus *Bouleiceras*. *Pecten ambongoensis* can also be matched by a number of specimens. This *Pecten* belongs to the same class as, and is closely related to, that already mentioned as occurring in the northern area. Thevenin's figures show perfectly the distortion of the left valve by the attachment area. This latter fact is sufficient to distinguish it from any other *Pecten*, and if Mr. Tipper's suggestion is correct, that it is due to fixation during part of its life, it ought to be raised to subgeneric rank. Similarly with *Sp. ros-*

trata var. *madagascarensis* and its different forms figured by Thevenin, these three examples as well as and many others show the close resemblance of the Porali river fauna to that of Madagascar.

Of the other forms occurring may be mentioned :—

Lima cf. *punctata* Sow.

Lima (*Plagiostoma*) *gigantea* Sow.

Pholadomya cf. *idea* d'Orb., and many others.

13. The opportunity was also taken by Mr. Tipper, while on study leave, of examining a small collection from the Belemnite Shales, a formation very widely developed in Baluchistan. The age of these shells was fixed by Dr. Noetling as Neocomian from the presence of *Belemnites* (*Duvalia*) *dilatata* Blainv. The known fauna is so small that any additions are of interest. Broken and unidentifiable ammonites have been collected by several observers, but the field-season 1905-06 yielded several well-preserved specimens. They have been identified as follows :—

Hoplites amblygonius Neum.—One specimen agreeing perfectly with Neumayr's species.

Olcostephanus sp., group of *O. asterianus*.—Although not specifically identifiable, there is no doubt that it belongs to this group.

Perisphinctes? sp.

Phylloceras cf. *velledæ* d'Orb.

Phylloceras sp.—Young form, perhaps the young of *Phyll.* cf. *velledæ*.

Crioceras sp.

In addition occur fragments of *Aptychi*, belonging to the groups *imbri-cati* and *punctati* of Zittel. This association is typically Neocomian, and bears out Noetling's correlation. From the presence of *Hoplites amblygonius* and *O. sp.* group of *asterianus*, the fauna may be considered as belonging to the Volgian type.

14. Messrs. E. H. Pascoe and G. de P. Cotter have added considerably to our knowledge of the palæontology of the Tertiary of Upper Burma. oil-bearing Tertiary strata in Upper Burma. Mr. Cotter has identified the collections made by the late Mr. L. G. Boyd of the Burma Oil Company in the Pegu series of Singu, Payagyigon-Ngashandaung, Padaung (near Prome), Kabat in the Myingyan district, Taungtha hill, and hills near Kwatalin, 20 miles south of Taungtha. The lists of species from each area are given in *Records*, Vol. XXXVI, pp. 131 and 132.

15. During the field-season 1906-07, marine fossils were found for the first time in the Pegu (Miocene) beds of the

Pegu beds.

Yenangyaung inlier, occurring at two horizons. Neither of these corresponds well with any of Dr. Noetling's zones, but the discovery proves that although the Pegu beds at Yenangyaung are less fossiliferous than at Singu, Yenangyat or Minbu, they were deposited under similar conditions. The questions are discussed by Mr. Pascoe in a paper published in the *Records* (Vol. XXXVI, Part 3). Among other fossils described Mr. Pascoe gave a provincial name, *Twingonia*, to a fairly abundant form then regarded as of doubtful zoological affinity but since identified as fish otoliths.

16. In addition to the classical locality, east of Minlindaung, from which

Freshwater fossils in the Pegu beds.

specimens of the freshwater forms *Batissa crawfurdi* and *B. petrolei* were first obtained by Crawford ninety years ago, Mr. Pascoe has found two others in which these two species occur and one yielding the gigantic *B. kodaungensis*. Distorted specimens of a variety of *B. crawfurdi*, named *yedwinensis*, have also been found in the Pegu beds, 300 feet below the Pegu-Irrawaddi boundary, thus pointing to the local, temporary establishment of freshwater conditions. These occurrences have been described by Mr. Pascoe in a special paper (*Rec. Geol. Surv. Ind., Vol. XXXVI, Part 3*).

17. Messrs. Pascoe and Cotter have described and figured (*Rec., Geol.*

Dendrophyllia.

Surv. Ind., Vol. XXXVI, Part 3, p. 147), a new species of the coral *Dendrophyllia*, *D. macroriana*, found in the Singu and Minbu fields.

18. The occurrence of an estuarine bed under Calcutta was described by Mr. E. Vredenburg in 1904.¹

Dr. N. Annandale, Superintendent of the Natural History Section, Indian Museum, has since identified the animal remains found. Most of the specimens collected are remains of molluscs, including *Telescopium fuscum* Ch., *Paludina* (*Vivipara*) *bengalensis* Lam., *Ampullaria globosa* Swains, *Aricia* (?) *moneta* Linn., *Planorbis exustus*, Desh., *Anomia achææ*, Gray, *Arca adamsiana*, Dkr., *Ostrea cucullata* Bow., and *Ostrea canadensis*, Tk. All these can be identified with living species, either in the freshwater tanks, in the brackish estuarine distributaries of the Ganges, or, in one case, in the clear sea-water. The most interesting is the last-named

¹ *Rec., Geol. Surv. Ind., XXXI, 174.*

oyster, which seems to have had a wide distribution, for the specimens found are not, as once suggested, imported to Calcutta as ship's ballast, the same species being found still living and common in the Sunderbans.

19. An occurrence of Lameta beds at Dongargaon in the Central Provinces was long ago brought into prominence by Hislop's discovery of fossil fish-remains.

Lameta Fossil Fish.

Recently some of the specimens collected at this locality came into possession of the Geological Survey, and Dr. A. Smith Woodward has now completed their examination (*Palæontologia Indica, New Series, Vol. III, No. 3*). All the remains appear to differ in specific characters from previously known forms, and three species have been distinguished. One of these, a Teleostean, is sufficiently strange to constitute a new genus, *Eoserranus*, while of the other two one is especially interesting, as it is the first-described specimen of the remarkable genus *Lepidosteus* that has been found in Asia, Dr. Woodward's description thus confirming Hislop's suspicion regarding the occurrence of this genus in the Lameta beds. All three genera have their nearest known relatives in the early Tertiary rocks of Europe and America. No true Percoid fish has been found hitherto in typical Cretaceous strata, and the oldest known member of the group to which *Eoserranus* belongs is *Prolates* of the Montian stage in France. *Lepidosteus* also ranges from the Lower Eocene to the Lower Miocene in Europe and from the Lower Eocene to Recent in North America, while the third genus, *Pycnodus*, represented in this collection has not been found outside the Eocene. Thus, judging by the evidence of the fossil fishes alone the age of the Lameta bed from which they were obtained would be between the Danian and Upper Eocene.

41. Captain F. L. Ditmas and Mr. S. D. Ware have sent to the

Gondwana plants, Pench valley.

Museum some fossil plants collected in the Pench valley coalfield between the villages of Dongor Porashea and the boundary of the Deccan Trap, north of the village of Hurreye. The specimens were obtained in an area marked as Barakar on the map accompanying the late Mr. E. J. Jones' memoir on the Satpura coalfields (*Mem., Geol. Surv., Ind., Vol. XXIV, Part I*), but according to the donors the beds are above the coal measures. The collection, identified by Babu Bankim Behari Gupta, Museum Assistant, includes *Phyllothea indica* Bunb., *Glossopteris indica* Schimp., *Gangamopteris cyclopteroides* Estm. and several other forms apparently new. The material identified is hardly sufficient to settle the age of the beds, and it is hoped that further discoveries of fossil

plants in this area will be made in order that the PENCH valley beds may be compared with the Mohpani coalfield, which, on the other side of the Satpura basin, has yielded Karharbari plants.

ECONOMIC ENQUIRIES.

Alum.

21. Mr. N. D. Daru was deputed to the Isakhel tahsil, Mianwali district, Punjab, early in the year, to report on the indigenous industry of alum manufacture and on the pyritous shales which were considered to be of possible value for the manufacture of sulphuric acid.

At Kalabagh the total length of the shale outcrop is about a mile and a half, with an average thickness of eight feet. About the same length of outcrop is accessible at Kotki, but the average thickness is four times as great, and the shale bed extends for eight miles east of Kotki. Patches only in the shale have been found to be rich enough for working. In these the average sulphur-content is 9.5 per cent., and there is besides bituminous matter present to the extent of about 3 per cent. The pyrite which mainly contributes to the sulphur-content is as a rule extremely comminuted, and can be distinguished only under the microscope. There is just a trace of gold in the shale. The shale is fissile to compact, light-gray to deep-black, and breaks with a conchoidal fracture. When freshly-mined it will take finger impressions, and when containing bituminous matter it has a greasy feel and can be easily given a lustre.

There is no systematic mining. The mines often are narrow, low, tortuous passages or screw-shaped shafts, and do not reach below the level of the adjoining springs. There is no provision for ventilating these hot mines and timbering is rarely found necessary.

At Kalabagh the alum manufacturer pays one rupee for twenty-five maunds of the shale; one-third of this amount going to the Malik of Kalabagh as royalty. At Kotki, the price is 35 maunds to the rupee, all of which goes to the miner.

The shale is roasted in the open, and there is considerable loss of sulphur dioxide. In roasting, the fresh shale is mixed with an equal quantity of previously used, but not quite exhausted, shale, which has been subjected to spontaneous oxidation for a year or more. The roasting is continuous, portions of the heap being cut away on one side

to supply the works, and fresh and old shale added on the other. Owing to the low sulphur-content, fuel has to be used.

The roasted shale is lixiviated, allowed to settle, and then boiled. When sufficiently concentrated, a mixture of crude chlorides, nitrates and sulphates of sodium (chiefly) and of potassium, is added, and the liquor transferred to crystallization tanks. When the crystals from these are removed after a week, the mother liquor is added to the fresh liquor from the roasted shale in the lixiviation tank. The crystals are allowed to accumulate for ten days, when they are fused in their water of crystallization, and the melt is poured into earthenware pots sunk into the ground. When it has recrystallized, the alum is ready for the market. The alum is mainly sodium-alum with a small proportion of potassium-alum. It goes to Delhi, Hissar, Sirsa and other centres of tanning and dyeing industries. The price of alum at Kalabagh in February 1908 was ₹4-12-0 a maund, and at the end of March 1908 it was ₹4-8-0.

The practice at Kotki is essentially the same as at Kalabagh. The output was 16 maunds a day at Kalabagh, where only one factory (which had been restarted on a rise of price of alum in November 1907 to ₹5 per maund) was working; at Kotki, each of the three factories, which work for only six or seven months in the year, has a daily output of 25 maunds. The annual output of Isakhel Tahsil may be put roughly at 20,000 maunds or 750 tons. Kalabagh, in spite of the high cost of shale there, can compete with Kotki owing to its proximity to the Indus and the railway, whereas Kotki manufacturers have to haul in part of their alkaline salts and haul out the whole of their alum output, by camel transport over a distance of nearly ten miles.

Improvements in the manner of roasting the shale, and in the construction of the fire-chamber for the boiling-pans are desirable. What is of perhaps greater importance still is the abandoning of the use of lime in the linings of the various tanks, and the substitution of plaster of Paris for it, there being plenty of gypsum near at hand. This change would probably prevent a waste of over six rupees' worth of the acid at each factory every day.

The alkaline salts come from Mandakhel and Kamar-Mashani in the Isakhel Tasil, Rokhri and Thatli near Mianwali, and Shahpur. At the first two places they are obtained by concentrating and crystallizing the product of lixiviation of the scrapings of the soil of the neighbourhood.

22. Mr. Daru visited the Dandot Colliery of the North-Western Railway, where pyritous shales are also known.

Dandot.

The shale here, on account of its high carbonaceous contents, is unfit for acid-making, but can be used for alum-making more advantageously than the shale of Isakhel Tahsil. The markets are 125 miles nearer, the source of the best alkalies is only half as distant as from Kalabagh.

China-clay.

23. In addition to an examination of the sands supposed to be of value for glass-making, Mr. Murray Stuart paid special attention to the clays of the Rajmahal hills said to be suitable for the manufacture of china and porcelain. Good material was found at three localities on the west of the hills, namely, Paturghatta near Colgong, Buskia near Katungi ($24^{\circ} 28'$; $87^{\circ} 29'$) and Dodhanee ($24^{\circ} 17'$; $87^{\circ} 29'$). There is evidence at the first-mentioned locality that the kaolin is of wide extent and that the quantity, speaking from a manufacturer's point of view, is unlimited. The quality of the clay is good, and it resembles strongly the Cornish china-clays. The extent of the deposits of kaolin at the other two localities is undetermined, but there are indications that there is a fair quantity at each place. In quality the clays from the last two localities seem to be equal to that of the clay obtained from Paturghatta.

In addition to these deposits, kaolin occurs in the white Damuda sandstone of the district and it is being extracted from the same sandstone at Mangal Hat near Rajmahal for use by the Calcutta Pottery Company. In quality it seems to be good and at Mangal Hat it is obtained very free from mica. On the west of the hills, however, the Damuda sandstone is more micaceous, and therefore would not be so suitable for the extraction of kaolin. Mr. Stuart's full report will be published in the *Records*.

Chromite.

24. In April Mr. Fermor paid a visit to an occurrence of chromite discovered in a serpentine at the Suru Pass on the road from Chaibasa to Senua, B. N. R., by Mr. R. Saubolle, prospecting on behalf of Messrs. Martin & Co. of Calcutta. Twelve small excavations had been made, and from each

Singbhum, Bengal.

chromite had been obtained. In three of them the chromite was seen *in situ*; it occurs as bed-like veins and disseminations in serpentine. These veins range up to about 10 inches in thickness, and in one of the pits formed a network. The junction between the chromite and the serpentine is usually sharp, but some specimens show a passage from chromite with very little serpentine, through serpentine containing disseminated grains of chromite, to serpentine practically free from chromite. The ore is of fairly high grade. A sample taken from the little stacks of ore—perhaps 10 tons in all—lying by the side of each opening, yielding 50·05 per cent. of sesquioxide of chromium Cr_2O_3 . Further prospecting has led to the discovery of other occurrences of chromite in this area; but none has yet been proved to be of commercial value.

Copper.

25. During the field season of 1907-08, geological and mineral work in Singbhum was continued by a party, consisting of Messrs. L. L. Fermor and K. A. K. Hallowes, with two students, Mr. G. G. Narke of Nagpur and Babu Kiran K. Sengupta of Calcutta, who were being instructed in methods of field-work. Mr. Fermor's time was spent in making a general examination of the ground with reference to the origin and mode of occurrence of the copper deposits, the relationships of the various rocks one to another, and the examination of various mineral deposits other than copper. The various portions of his work are noticed under petrology, chromite, iron, and manganese. With regard to the mode of occurrence and origin of the copper deposits he is in more or less general agreement with Mr. Hallowes' conclusions and descriptions, as embodied in his progress reports.

Mr. Hallowes took up his work where he left it in the previous season, namely, at Matigara in Dhalbhum, and continued the examination of the copper belt to the south-east and south-south-east as far as Bhairagora near the Mourbhanj border, beyond which locality he was not able to find any further old copper workings; all his work this season thus lay in the Dhalbhum Estate. Old copper workings are now known to occur at intervals along a belt stretching for some 80 miles from Duarpam on the Bamini River in the Kera Estate on the extreme west, through the Kharsawan and Saraikala States. So far the general trend of the belt is practically due east; but on entering the Dhalbhum Estate,

within which it lies for the remainder of its course, at Landup the strike of the belt curves round to south-east, running through the Rajdoha and Matigara properties of the Rajdoha Copper Company, Limited, and then through the wild south-east portions of Dhalbhum to Bhairagora, at the extreme south-east end of the belt. This curving round of the strike is an expression of the fact that throughout its course the strike of the copper belt follows that of the Dharwar schists and phyllites in which the copper deposits occur; the strike of the Dharwar rocks themselves is determined by the shape of the enormous area of granite occupying central and southern Singbhum, as they dip away from it everywhere.

The copper-ores occur as rather indefinite lodes interbedded with the Dharwar phyllites and schists; sometimes the ore is collected into fairly well defined bands, but very frequently it occurs in the form of grains disseminated through a considerable thickness of schists so sparsely as to be unworkable; whereas if the same amount of copper minerals had been concentrated into smaller thickness of schists workable deposits of ore would have been formed. When concentrated into definite lodes, as at Matigara, the ore may be of fairly high grade, and well worth working if it can be proved to exist in sufficient quantity to render it worth while to erect the plant necessary to handle large quantities of ore. The development work being carried out from the Gladstone shaft in the Matigara mine by the Cape Copper Company, on an option held from the Rajdoha Copper Company, has given somewhat encouraging results, but, until a considerably larger amount of drilling and underground development has been accomplished, it will not be possible to speak with certainty of the prospects of this mine. As seen at the outcrops the lodes seem to be very poor indeed, where they have not been removed by the ancients. Typically, they consist of small thicknesses of vein quartz, associated with malachite, chrysocolla, and red oxides of iron containing a small quantity of copper, possibly as red oxide, with sometimes small encrustations of libethenite. In depth, as seen in the diamond-drill cores and the levels of the Matigara mine, the ores consist practically entirely of chalcopyrite. The other minerals noticed above are evidently the outcrop alteration products of the yellow sulphide. Judging from small specimens found on the dump heaps of the old workings there must be a zone of chalcocite not very many feet below the surface, probably formed by secondary enrichment at the expense of the portions of the deposits denuded away, and of those now appearing as gossans of oxide ores. The primary chalcopyrite ores have probably been deposited in

their position as rather indefinite lodes following the bedding of the schists, subsequent to the arrival of the schists in their present position. The schists with which the copper lodes are associated are chiefly varieties of muscovite and chlorite-quartz-schists, with quartz layers. Apatite and tourmaline are also common minerals in these schists.

The diamond drilling accomplished during the year included :—

- (a) *Matigara*, three miles west of Moholia, B. N. R., in the Dhalbhum Estate. This hole was put down to a depth of 837 feet to test the extension in depth of the lode exposed at a depth of 229 feet in the Gladstone shaft, the Cape Copper Company bearing half the expense of the hole. The most valuable portion of the lode was cut at a depth of 736 feet from the surface, but the rocks were cupriferous for a vertical distance of 46 feet (dip of lode = 38°). The cores were assayed in sections by Mr. Hallowes with the following results :—

Portion of core.	Actual thickness.	Copper.
693'—697'	3'15'	2'0 per cent.
697'—701' 8"	3'67'	1'29 "
733' 5"—736' 1"	2'10'	1'01 "
730' 1"—736' 5"	0'26'	12'81 "
736' 5"—739'	2'03'	0'42 "

- (b) *Lankisra*, to the south-west of Gharsila in Dhalbhum. This hole was put down to a depth of 392 feet to test a lode indicated by some old workings. The cores were found to be noticeably cupriferous between the depths of 150 and 184 feet. Taking the dip of the rocks as 21° the thickness of cupriferous rock or 'lode' is about 23 feet. The lode was assayed by Messrs. Snelus and Duff of the Cape Copper Company, with the following results :—

Position of core.	Actual thickness.	Copper.
150'—168'	16'80'	2'65 per cent.
169'—171'	1'86'	2'13 "
179'—184'	4'66'	1'37 "

The results of these borings confirm those previously obtained, showing that generally speaking the ores of Singbhum are of low grade, and on the whole just below what is likely to be payable, except when working on very large quantities of ore. A thickness of 16·80 feet, averaging 2·65 per cent. copper found at Laukisra, should, however, lead to the further testing of this occurrence by private enterprise. The 3-inch layer of ore giving 12·81 per cent. copper found at 736 feet in the Matigara hole is also of considerable interest, because this band happens to be identical in its mineral peculiarities with a persistent band of chalcopyrite, with blebs of quartz, ranging from 6 inches to 2 feet in thickness and found in the Matigara mine at a depth of 228 feet. It may so happen that at the depth of 736 feet the drill passed through a very thin portion of this characteristic band of ore, which is typically very variable in thickness. The encouraging feature is that this hole indicates the persistence of this band of rich ore from the depth of 228 feet to that of 736 feet. The Geological Survey drills have been lent to the Cape Copper Company, which is now further testing the Matigara lodes.

Engineering Questions.

26. At the request of the Chief Engineer, United Provinces and of the Consulting Engineer for Protective Works in Central India, Mr. LaTouche reported on the geological features of certain sites selected as suitable for reservoirs and canal heads. These include :—(1) Murwari, on the Ken river in the Panna State, at the point where the river issues from the scarp of Upper Vindhyan sandstones and shales near the southern boundary of Bundelkhand; (2) Kota, on the Bairma river, a tributary of the Ken, at the foot of the same scarp further west; (3) Gangao, where the Ken river issues from a gorge in the Lower Vindhyan sandstones at the head of the plateau of northern Bundelkhand; (4) a weir site on the Ohen river near Karwi, in Vindhyan sandstones; (5) a canal head on the Paisuni river, also near Karwi, where it is proposed to build the dam on a band of Vindhyan limestone, which forms a bar across the river; and (6) a dam in course of construction at Pahari on the Dhasan river near Harpalpur, where the foundation consists of Bundelkhand gneiss traversed by dykes of basic rock.

Fire-clay.

27. While examining the china-clay deposits of the Rajmahal hills, Mr. Murray Stuart recorded notes regarding some deposits of excellent fire-clay in the Hura, Chuperbhita and Pachwara coalfields. The deposits are rather difficult of access at present and are not very large, being distributed through the fields in beds seldom exceeding six feet in thickness.

Glass-making Sands.

28. Mr. Murray Stuart was deputed to the Rajmahal hills in January to examine certain occurrences of sand reported to be suitable for glass-making, and his report is published as a separate paper in *Records, Volume XXXVII, Part 2*.

He concludes that the sand met with in this area is generally unsuitable for the manufacture of any but the commonest kinds of bottles. Sands occur as—

- (a) recent river-sands, and
- (b) Damuda (Gondwana) sandstone.

The river sands, of which the Ganges sand is the purest and most free from iron, yield a dark-green glass, which is only suitable for the cheapest beer—and wine—bottles, and is too dark to be affected by the admixture of manganese with the raw materials before fusion.

The white Damuda sandstone yields a sand with a high percentage of silica, and is the one mentioned by Mr. J. G. Cumming, I.C.S., in his report on the Industrial position and prospects in Bengal in 1903 (page 28, paragraph 2). The sand obtained from this sandstone yields a glass which is only faintly coloured by iron; consequently, by the admixture of manganese with the raw materials before fusion, a colourless crystal glass can be obtained. The objection to the use of this sand for glass-manufacture lies in the fact that it contains a somewhat large quantity of kaolin which it is practically impossible to eradicate under working conditions. The result of this kaolin is that the glass contains small inclusions, about the size of a pin's head, of a white opaque substance which is practically pottery; this of course renders the sand of little value for glass-manufacture, as no increase in temperature will affect the inclusions.

Gypsum.

29. Information having been received from the Collector of Hamirpur District in the United Provinces that deposits of gypsum had been found at several places near the Bairma river, a tributary of the Betwa, Mr. LaTouche was deputed to examine them, as it was thought that, if the deposits formed a continuous bed, such as their reported mode of occurrence seemed to imply, they might possibly be of Lower Tertiary age, and afford a clue to the presence of Tertiary strata along the southern edge of the Gangetic basin beneath the alluvium. The examination of the beds, however, disclosed the following facts :—

- (1) That the gypsum, in the form of crystals of selenite, is entirely confined to the older alluvium in the neighbourhood of the rivers, and that it is of recent origin.
- (2) That the crystals are found at certain definite spots at a depth of from 4 to 6 feet over very limited areas, the largest of which, near the village of Puraini, measured about 600 square yards, and that the mineral does not form a continuous bed or layer, being very limited in quantity.
- (3) That the selenite crystals appear to have been deposited in a plastic clay occurring at these spots by water percolating from below, holding sulphate of lime in solution, and evaporating before reaching the surface.

Iron-ore.

30. Whilst working in the Singbhum copper area Mr. Fermor took the opportunity to examine various deposits of iron-ore being developed by the Bengal Iron & Steel Co. for their smelting works at Kulti.

These may be divided into two groups—the Turamdih deposits, some 4 miles from Kalimati, Bengal Nagpur Railway ; and the Hakigora deposits, some 8 miles from Kalimati, and separated from Turamdih by a high intervening range of hills, which may be called the Dhoba Hills ; this is composed of quartzites, slates, and phyllites of Dharwar age, which is also the age of the rocks with which both groups of iron-ores are associated.

The Turamdih deposits occur in some foot-hills at the north base of the Dhoba Hills in the villages of Talsa, Turamdih, and Kudada. The ore is magnetite ; it is found in a series of schistose magnesian rocks, which have not yet been closely studied, but which contain steatite, as an important constituent. The magnetite occurs in the magnesian schists in four ways :—

- (1) as scattered granules ;
- (2) as large patches of irregular shape ;
- (3) as definite veins traversing the magnesian rocks in any direction ;
- (4) as veins up to 3 feet thick, composed of magnetite, with vein quartz, secondary limonite and chert.

The magnetite is probably the result of segregation from the igneous rocks from which the magnesian rocks have doubtless been derived. At the surface the magnesian schists have been much weathered, with the liberation from its matrix of a large quantity of magnetite in the form of granules and small lumps. These are recovered by sifting and picking by women and children, and form the chief portion of the ore won here. A certain quantity is, however, obtained *in situ*, by following up the thicker veins in open excavations.

The Hakigora ores occur in some small hills to the south of the Dhoba range. They consist of the banded magnetite and hematite quartzites so typical of the Dharwars in many parts of India. As at Turamdih the chief source of the ore is a detrital deposit formed by the breaking down of these ferruginous quartzites, in the course of which the layers of iron-ore are to a certain extent separated from those of quartzite. A small quantity of ore is also won by working the rock *in situ*, wherever there happen to be bands of iron-ore of sufficient thickness.

Manganese.

31. During the year Mr. Fermor completed his monograph on the Manganese-ore Deposits of India, issued as Volume XXXVII of the *Memoirs*. The chief results, briefly mentioned in previous Reports, are now brought together in a form that will be of great practical value to those engaged in manganese mining ; but the work is equally important as a contribution to the purely scientific questions connected with the ore-deposits and associated rocks. From every point of view this memoir

supersedes anything hitherto published on manganese-ores, and will take a prominent place in geological literature.

32. In January, 1908, Mr. Fermor visited two deposits of manganese-ore discovered since his previous visit to this district (in 1905). One of these—

Singbhum, Bengal

Tutugutu, near Chaibasa—is exactly like those previously examined in this area. The other is Leda Hill, which rises to a height of about 1,000 feet above the plains level near Goilkora, Bengal-Nagpur Railway. It is the only example in the district of a manganese-ore deposit occupying the top of a hill. But like the deposits of the Chaibasa area, this deposit has been formed by the superficial replacement of Dharwar slates, phyllites, and quartzites. The quantity of merchantable ore is small.

33. In November, during a visit of inspection to some of the manganese mines of the Central Provinces, Mr.

Central Provinces.

Fermor obtained at the Gowari Warhona deposit in the Chhindwara district, an important piece of evidence bearing on the age of the manganese-ores. Now that this mine has become deeper it is found that the manganese-ore band, which at the surface was fairly continuous, is much broken up by pegmatitic intrusions. These are seen abruptly truncating the beds of manganese-ore; and in one place a thin vein of pegmatitic rock was seen traversing the manganese-ore beds, and containing a small isolated inclusion of high-grade manganese-ore identical in physical appearance with the ore on either side of the vein. From this it is evident that the high-grade manganese-ore of this part of the mine was in existence at the time of intrusion of the pegmatitic rocks; the date of the latter is to be regarded as Archæan in the absence of evidence to the contrary; and hence it seems fairly certain that a portion at least of the manganese-ore of the Central Provinces was in existence in Archæan times, so that the present position of the deposits can have no genetic relation to the surface of the ground, and therefore the deposits may be expected to continue to depths that have no relation to the level of ground water, *i. e.*, possibly to very considerable depths. The deductions drawn from this occurrence at Gowari Warhona agree with certain evidences of intrusion of pegmatitic rocks into manganese-ores obtained at other deposits in the Central Provinces.

34. In December, Mr. Fermor visited some manganese-ore deposits opened up during the year in Gangpur State in Bengal. These are of considerable

Gangpur State.

interest, because the ores contain braunite, and are associated with spessartite and rhodonite. In fact the occurrences resemble in every way the deposits typical of the Central Provinces rather than the superficial deposits of Singbhum, the only other part of Bengal in which manganese-ore deposits of any note have been located. The discovery of the gondite series in Gangpur is of considerable interest, since it means that this series has now been found at intervals over a belt, aligned roughly east and west for a distance of 700 miles, extending from Jhabua and Narukot on the west, through the Nagpur-Balaghat area of the Central Provinces, to Gangpur State in Bengal on the east. The gap between the western exposures and the Central Provinces is largely occupied by the Deccan Trap formation; but in Chhatisgarh, occupying the gap between the Balaghat district and Gangpur, there are several areas of Archæan rocks, and consequently it will not be surprising if future prospecting leads to the location in this area of manganese ore deposits associated with gonditic rocks. The Gariajhor deposit in Gangpur seems to be of considerable value, the ore being first grade; owing to the small lead to the sea board as compared with the Central Provinces, it will be possible to export ore at a profit from this deposit at times when most of the mines of the Central Provinces are closed down.

35. While on duty at Nagpur in connection with the Central Provinces and Berar Exhibition in November and December, 1908, Mr. Fermor was also deputed to make a third inspection of the manganese quarries. During this tour the following deposits were visited :—

**Inspection of mines,
Central Provinces.**

Chhindwara District.—Gowari Warhona, worked by the Indian Manganese Company, Limited.

Nagpur District.—Mansar and Kandri, worked by the Central Provinces Prospecting Syndicate, Limited; Kacharwahi and Pali, worked by the Central India Mining Company, Limited.

Bhandara District.—Chikhla, worked by the Central Provinces Prospecting Syndicate, Limited; Kosumbah and Sukli, worked by the Central India Mining Company, Limited.

Balaghat District.—Thirori, worked by Mr. D. Laxminarayan.

As in all his previous work on the manganese-ore deposits of the Central Provinces, Mr. Fermor received the friendly assistance of the managers, and his report has been submitted to the Central Provinces Administration for communication to the Companies concerned.

As a result of his investigation Mr. Fermor is satisfied that there is now a general desire throughout the manganese area to work the deposits on sound principles, and in many cases considerable expenditure has been incurred in developing deposits by improved methods.

The point on which the future of the manganese industry of the Central Provinces turns is whether or no the manganese-ore deposits continue of workable quality to any depth below the surface, or whether they are purely superficial in their mode of occurrence. Judging from the evidence discussed on page 27 it will be seen that some of the deposits probably continue to considerable depths. But this question cannot be settled satisfactorily until some of the typical deposits are tested by boring. When, in any given case, a company wishes to plan out the underground working of a deposit it will be wise first to test the deposit by boring to as great a depth as it is proposed to work it.

Petroleum.

36. The first three months, up to the third week in January, were spent by Mr. Pascoe on the Yenangyaung Oil-field. Part of this period was spent in office work and in the consideration of the numerous points connected with the proper development of those portions of the field known as the Twingôn and Bémé Reserves. The rest of the time was taken up with the completion of the geological map of the Pegu inlier enclosing the oil-field. The anticline, on its flanks, is studded with small dip-faults, which, though unimportant in size, are interesting as indicating the direction of strain at the time the post-Irrawadi sandstone fold was produced. The direction of the anticlinal axis is 28° W. of N. to 28° E. of S., whilst the general average direction of these faults is north-east to south-west. Besides these flank faults, which are usually observed crossing and displacing the boundary bed between the Pegu beds and the Irrawadi sandstone, there are numbers of minute faults or slips having no constant system of orientation, in the more central area including the crest. Some of them may very possibly account for some of the anomalies in the petroliferous horizons. Around and south of Bémé mud veins take the place of these faults and in some cases are actually widened and plugged faults: they probably represent some former outflow of mud in the form of "mud volcanoes," which have since been entirely removed.

February was spent in the Lower Chindwin District, examining the numerous oil indications west of Kani and Kin. Small quantities of oil have been obtained by Burmans by digging pits, and these as well as natural seepages, occur on or near the crest of an anticline similar in structure to that of Yenangyat, having steep or vertical dips on its eastern, and comparatively gentle ones on its western flank. The rocks consist largely of hard impure limestone or calcareous sandstone, and conglomerate with limestone pebbles. The impervious nature and consequent small liquid-retaining capacity of the strata, as well as the dense and often impenetrable jungle clothing the hills, render prospecting hazardous and unpromising. The petroliferous rocks are presumably of Pegu age, as they are succeeded eastwards by fossil-wood-bearing, soft sands of the ordinary Irrawadi sandstone type.

The rest of the season was spent on the volcano, Mount Popa, in the Myingyan district. The bulk of the volcanic material is evidently post-Irrawadi sandstone in age, but a thin bed of ash and tuff intercalated among the latter sediments shews that activity commenced before the end of that period. The volcanic deposits consist mostly of conglomerates, tuffs, ash and andesitic lava flows.

37. After initiating Mr. Sethu Rama Rau into his work at Singu, Mr. Cotter commenced at the end of November an examination of the southern portion of the Gwegyo Hills in the Myingyan District, and early in December continued his survey southwards along the same fold, including the Payagyigon-Ngashandaung Oil-field. The results of this work have already been published (*Rec., Geol. Surv., Ind., Vol. XXXVII, Part 3.*) In February Mr. Cotter removed to the Pakòkku District. The hills north of Myaing village were found to consist of igneous rock, and an examination of the country around the oil seepages near Kyaukwet and Seewin shewed that the area was one of great faulting and contortion. In the latter region there is no simple anticlinal structure and the prospects of obtaining oil in any quantity are problematical. One point of some interest was the occurrence here of fossil-wood and marine fossils (*Pecten, Turritella*, etc.) in the same conglomerate.

With the exception of a brief visit, at the request of the Burma Government, to the Taungu stone quarries, the rest of the season was spent on the northern part of the Yenangyat Oil-field. The results of the latter will very shortly be published.

38. With the exception of about two months around Yenangyat and a brief visit to Thayetmyo, this season was spent on the Singu Oil-field, mapping the various fossil bands in the Pegu series. Some of these were traceable for a considerable distance, and could be recognised on both sides of the anticlinal crest. The fossil bands mapped were sufficient to demonstrate nicely the structure of this portion of the fold, and should be of some assistance in drawing the boundaries of the oil pools in the separate sands. Among the fossiliferous bands is one noticed by Grimes as the basal bed of Noetling's Yenangyaungian stage, consisting of a fissile clay containing sandy nodules, in each of which is found a cast of a fossil, usually *Tellina* or *Cardium*: these nodules recall forcibly the "box-stones" of the English Red Crag. Another easily recognisable horizon, low down in the series, is characterised by abundance of the coral *Dendrophyllia macro-rana*: this horizon was also identified at Yenangyat. Several specimens of *Batissa kodaungensis* were found along the Pegu-Irrawadi boundary bed in block 28, Yenangyat. In block 31, Yenangyat, many specimens of a *Melania* were found in the red boundary bed. Two or three dip-faults were traced in the Singu field, the most conspicuous running through blocks 55° N. and 56° N. The boundary also between the Pegu and Irrawadi series (both in Singu and Yenangyat) is described as a strike fault.

39. Mr. Cotter has published an account of his observations on the

Results published.

Tertiary strata in the Taungtha hills in the Myingyan District. He finds the structure of these hills to be that of an asymmetric saddle-shaped anticline, or a single fold comprising two united elliptical domes, the direction of the axis being 30° west of north. Faults occur, but the most interesting point observed was the nature of the asymmetry of the anticline. Contrary to the usual condition, it is the dips on the west of the crest which are steep, while those on the east are gentle.

Taungtha Hills.

The hills consist of Pegu beds as shown by fossils and the occurrence of selenite. The rocks have been subjected to considerable pressure, and Mr. Cotter concludes that the prospects of obtaining oil in this area are poor, owing to contortion and faulting (*Rec., Geol. Surv. Ind., Vol. XXXVI, Part 3, p. 149*).

40. Mr. Cotter has also summarised his work on the southern part of

Gwegyo Hills.

the Gwegyo hills, including the Payagyigon-Ngashandaung Oil-field (*Rec., Geol. Surv. Ind., Vol. XXXVII, Part 3.*)

The field-work was undertaken in December 1907 and January 1908 in order to obtain some idea of the prospects of oil-prospecting at this end of the Gwegyo anticline. The most characteristic feature in the Pegu beds is the great predominance of soft shale over sandstone, and the consequent flatness of the country. The thickness of Pegu rocks exposed near Nyaungnigyin is perhaps over 4,000 feet, and the junction of these beds with the Irrawadi sandstone on the east is a faulted one. In the Payagyigon-Ngashandaung area the eastern junction is faulted in an exactly similar manner, and the western junction is probably an unconformable one: the fault, as in the northern part of the anticline, appears to have occurred along or very close to the crest. Numerous fossils, including two species of *Nautilus*, were found in this southern area, and the evidence points to a marine origin for these beds. Oil has been obtained here, but the prospects of obtaining it in paying quantities are poor. A remnant of the crest of the fold exists in block 5, but the anticline is pitching southwards.

41. My services were placed at the disposal of the Government of

Burma from the 1st September to preside over a Committee appointed to investigate the present conditions of exploiting the Twingôn and Bémé Reserves in the Yenangyaung Oil-field, to examine the alleged dangers arising from flooding, fire and wasteful methods of working, and to make proposals for the better government of the field.

After examining the information obtainable from the companies' agents at Rangoon, the Committee proceeded to Yenangyaung and collected information on the ground.

The reserved areas of Twingôn and Bémé cover jointly an area of about 450 acres, lying about $\frac{1}{4}$ mile apart, and separated from each other by the Khodaung block which is leased to the Burma Oil Company. The surface area of both Reserves is intersected by deep ravines, many of them having precipitous sides. The Twingôn Reserve having proved to be, by far, the richer in oil has been most thoroughly exploited, and it is in this area only that the close drilling and dovetailing of independent companies with the Twinzas (still working with the primitive system of hand-dug wells) is distinctly marked; it is consequently in this area only that the dangers feared are imminent, especially in the central part of the Reserve known as the Aungban. At the time of the Committee's visit there were 145 drilled wells in this Reserve together with 333 Burmese hand-dug wells, and of the drilled wells 76 were concentrated

on an area of only 46 acres in the Aungban. In this section of the Reserve sites of only 60 feet square were valued and sold at prices often exceeding Rs. 40,000.

The Committee were convinced, as the result of examining the history of numerous wells, that those in close proximity often drain the same oil-sand below, and consequently affect one another in production. The sand-banks in which the oil is stored appeared, however, to be so irregular in shape that no constant rule could be laid down for the way in which the adjoining wells affect one another's supplies of oil; but it was evident that cases of mutual interference were sufficiently numerous to impress the companies with the desirability of rapid drilling in competition with their neighbours; consequently hasty drilling incurred dangers of fire, and (by the imperfect shutting off of oil-sands) danger of water penetrating and interfering with the productive capacity of the oil-sands.

As regards the dangers of fire the Committee noticed that no attempts were made to provide lightning conductors for the tall wooden derricks, and no guy-ropes were provided to pull the derricks over in any safe direction during fire. The oil in the receiving tanks near each derrick was measured by the use of a dip-rod inserted through a hole in the cover of the tanks, and the measurements being made by uneducated subordinates, who were only partially aware of the dangers involved, considerable risk was incurred by the use of naked lamps at night. Forges for dressing bits and boilers for driving the pumping and drilling engines were scattered indiscriminately among the wells, and were a source of constant danger in consequence of the frequent incoming of new spouting wells. The hand-dug Burmese wells were distributed irregularly among the drilled wells and were worked by people who are habitual smokers under conditions that would lead to a serious loss of life in case of any widely-spread fire. Casual strangers and pedestrians ignorant of the dangers around them were allowed free access to the congested part of the field. No provision had been made for the cutting off of flowing wells during fires, and the whole area was covered naturally with a network of oil and gas pipes. Although the drillers were generally fairly cognisant of the dangers around them, and a general understanding had been established as to the precautions that ought to be observed, it was evident that in a field already congested and likely still more to be developed with sharp competition, there was urgent necessity for detailed and exact regulations.

It had been alleged that, in consequence of the rapid exploitation of the oil, there was a tendency for the sands to become clogged by paraffin,

with a consequent reduction in the total quantity of oil obtainable by drilling; but the committee found that the deposition of paraffin could not in any way reduce the amount of oil finally extracted from the field.

A number of schemes were discussed for the resettlement of holdings in order to divide the interests into sufficiently large areas to prevent the ill-effects of competition and consequent hasty drilling. They found, however, in consequence of the objections raised by the companies themselves and the difficulty of treating the *Twinzayos* equitably, that the present system of ownership could not be disturbed, and that it was possible only to take steps to regulate the work of oil-winning in the Reserves. They consequently drew up a series of proposals for enforcement through a new Regulation. They suggested the appointment of a Warden for the field, who would have the powers and duties of a first-class magistrate, and they suggested that he should be assisted by an Advisory Board composed of one officer of the Geological Survey together with two members nominated by the Oil Companies themselves. They made proposals for the allotment of new sites and for the distribution of those sites which had been resumed by Government in consequence of breaches of the conditions under which they were originally allotted. They also formulated rules for the control of operations whilst drilling through water-bearing sands, and for governing surface operations likely to incur danger from fires. Proposals were also made for revising the form of grant in order to make it consistent with the new regulations. The companies having unanimously agreed provisionally to accept the proposed regulations, steps are now being taken to put the proposals into law by the Burma Government.

42. At the request of the Punjab Government, Mr. Daru while in the Mianwali district studying the alum shales, also visited the oil-springs at Jaba in the same district. The total monthly output from ten springs is about 50 gallons only of thick, dark-green, sulphuretted oil. He found the strata to be so disturbed that he doubted the feasibility of obtaining larger supplies.

Salt.

43. In the General Report for 1907 (*Records, Vol. XXXVII, p. 37*) reference was made to the theory which I had offered to account for the origin of the salt accumulations in the Rajputana desert. Dr. W. A. K. Christie having

designed the apparatus required to sample the desert winds and having made a series of preliminary tests under laboratory conditions, volunteered to undertake the work in the desert during the hot weather of 1908. He set up his apparatus near Pachbadra ($25^{\circ} 55' \text{ N.}$; $72^{\circ} 11' \text{ E.}$) in April and carried on daily observations until early in June when Sub-Assistant Vinayak Rao carried on the field work alone. Both officers deserve the greatest praise for the way in which they cheerfully faced the hardships of camp life in the desert during the hottest part of the year.

Observations were made throughout each day regarding the speed of the wind and the atmospheric temperature and pressure. Samples were collected at regular intervals until the burst of the monsoon in July, and these, with samples of sand and rain, were afterwards investigated by Dr. Christie at headquarters. A joint paper will shortly be issued by Dr. Christie and myself detailing the results of this interesting enquiry, and the following are our chief conclusions:—

It has now been shown by actual observation during the hot weather that large quantities of sodium chloride in the form of fine, dry dust are carried into the desert region of Rajputana from the south-south-west. Concluding from the daily observations made at Pachbadra during the hot weather of 1908, the amount of salt passing a front 300 km. broad and 100 m. high during the four hot-weather months might be indicated as 130,000 tons. The hot weather of 1908 was a season of unusually weak winds, and this figure (which has little more than qualitative value) is probably well below the annual average influx of salt dust.

When it is known that these hot winds blow steadily towards the north-north-east for three or four months every year, that they are strongest (often attaining the speed of gales), during the day time when the salt dust is dried by the scorching sun under a cloudless sky, that there is no reflux and very little variation in direction, with a gradually diminishing speed as the heart of the desert is approached, and that the period of hot, dry, southerly winds is followed always by a downpour of rain, with the formation of a lake in each small area of internal drainage in the Rajputana desert, it is easy to account for the great accumulations of saline silt which are left after the annual desiccation of the salt lakes.

These winds from the south-south-west blow over the arm of the sea known as the Ran of Cutch, which is covered with a layer of white salt during the hot, dry season. Every disturbance of this crust by pedestrians and animals helps to form the salt dust which is wafted away towards Rajputana. The winds blow strongly in the day time, with a lull at nights, but the movement is all in one direction at the time of year when the dust is dry and can be carried most easily; and there is no set-back until after the monsoon period of rain, when all the finely-divided salt dust that may have reached the heart of the desert is washed into the hollows occupied by brine lakes. The strength of these winds is indicated by the fact that small

foraminifera have been carried bodily (not rolled) as far as 500 miles inland from the coast of Cutch.

An idea of the quantities of salt to be accounted for is given by a special examination of the Sambhar Lake: the silt of this lake partly fills a depression in the Aravalli schist "country;" it has been shown by two borings that the silt is about 70 feet thick in places, and, as the result of detailed samplings at regular intervals, it has been shown that the uppermost 12 feet of this silt over an area of 68 square miles includes 55,000,000 tons of sodium chloride. There are many other smaller salt lakes of the Sambhar type on the Rajputana highlands, and there may be many such bodies of silt buried under the mantle of sand.

We consider that the action of the wind alone is sufficient to account for the large accumulations of salt in Rajputana. The instance is one of special importance from the circumstance that on the Rajputana highlands no other explanation offered will account for any but unimportant quantities of salt; there are no inflowing large rivers; there are no traces of ancient rock salt deposits; no known saline springs; no likelihood of subterranean water rising to the surface; no probable connection throughout most of the areas lying on the crystalline schists with the water which is possibly percolating underground from the lower-lying Punjab plains towards the still lower depression of the Indus valley.

While admitting that rock-salt deposits may be formed in other ways also, our observations in Rajputana go far to strengthen the evidences gathered by the late J. Lomas and others to show that many rock-salt deposits, like those in the British Trias, are dependent on desert conditions. Large desert-areas are regions of indraught during the hot, dry seasons, when any salt available is easily pulverised. Where these are regions of internal drainage, the salt becomes "fixed" in local hollows after rain; in the Rajputana salt-lake region we find deposits of gypsum, nodular limestone, and plano-convex, lenticular masses of calcareous mud stained black with ferrous sulphide, which, on oxidation would give rise to the red colour so characteristic of the marls and sands associated with rock-salt deposits.

The well known estimates of the age of the ocean made by Professor J. Joly included a ten-per-cent. correction due to the sea-salt carried inland by winds and brought down by rain to add to the quantity carried to the ocean by rivers. References to the salt carried inland by sea breezes have generally assumed that the principal quantities leave the ocean as fine spray; but it appears from our observations that, under special conditions like those in Western India, where a desert region forms the hinterland of a salt-incrusted temporary arm of the sea, far larger quantities of sea-salt may be carried inland as finely divided dust. It is impossible, however, to say from our results that Professor Joly's allowance for sea-salt in river waters should be materially increased. The process by which the salt is formed in the Ran of Cutch tends to eliminate the rarer and more soluble magnesium and potassium salts, leaving the wind-borne chloride to be more purely that of sodium than would be the result of an inland transportation of simple sea-spray. The iodine and bromine in the Sambhar brines are found to be in a smaller ratio to the chlorine than in sea-water, possibly for a similar reason, but these two halogens bear in Sambhar just the same ratio to one another as they do in the sea.

Tin.

44. Mr. Page continued his survey of the Mergui district, devoting the first quarter of the year to an examination of the archipelago. In these islands granite forms the prevailing rock-feature, and it occurs both in the gneissoid form apparently similar to the usual Archæan gneiss, and in a distinctly intrusive form, the latter penetrating both the older granitoid gneisses and the sedimentaries.

The islands in which granite was observed may be divided into six groups:—

- (1) The western group, consisting of Moscos, Metcalfe, Great Western Torres, Hayes, Fetcher and Clara. All the intermediate parts of this outer group are also probably granitic. Both kinds of granite were observed in this group.
- (2) An ill-defined group comprising the western part of Elphinstone, south-east Elphinstone, Grant, the northern half of Ross, Maingay's and smaller islands as far east as Cantor. The larger portion is of gneissose granite, into which the younger granites, and numerous quartz porphyry dykes have penetrated.
- (3) A large domed outcrop, a little south of King's Island Sound, all the south of King's, Mergui, Sellore, Tucker, Julian, and the central ranges of Kissering. In this group gneissose granites predominate.
- (4) Parker and Domel down to and including High Island form another series of basal granites; they may be traced north through the Pickwick group into Cantor and south through the Gregories and down the coast to Victoria Point and the adjacent islands.
- (5) Davies Island is apparently an isolated granite outcrop, but extremely bad weather prevented the adjacent islands being carefully examined, and there may be granites in the interior of St. Matthew's.
- (6) Koolagyun, and the low islands mostly covered by swamp, which extend for miles down the coast, are composed of granite, usually of the basal variety with intrusive granites and pegmatite veins penetrating them in all directions.

Quartz-porphyrries form a very important factor in group 2. They occur intrusive into granites and the sedimentaries. Mount Elphinstone (west coast Elphinstone Islands), the peak on Maingay's, and Cantor are all examples of intrusion into granites; and Hayes, Julia, the extreme south of Cantor and some islands east of Ross show examples of intrusions into slates. Johnny, Paton, Allan and other islands near are composed for the most part, if not entirely, of quartz-porphyrries.

45. Above the granitic rocks there is a series of indurated sandstones, quartzites, slates and schists. These rocks are as a rule much crushed, at times sparsely mineralised, and generally do not cover any considerable area. They are usually met with in small mountain streams. Above these comes a series of slates, sandstones, grits and conglomerates. But they are not always all present, denudation having generally removed the last-mentioned rocks. As far as is known Pataw is the only island formed of conglomerate. The series may be observed in the following groups of islands: Central Kings, some 7 miles from the east coast line, Iron, the north-east of Maingay's island and the adjacent islands, central and north-east Elphinstone, Macleod's, Southern Ross and adjacent islands, the Warden, Christmas, Bentinck, the Five Sisters, St. Luke's, St. Matthew's in parts, Bushby, Father and Son, Lord Loughborough, and Governor Swinton and Cavern are all of sandstone and belong to the lower part of the Mergui series. Hayes, Julia, Cantor (South end) and Sullivan are all slate islands, and may be classed with the above.

In connection with the above sedimentaries, there is a series of sandstones, slates, and breccia-conglomerates which at times exhibit a schistose character, and are difficult to connect with the lower part of the series. They dip irregularly and show the effects of the intrusive granites to a much more marked extent than the older group. These formations may be seen in islands near to and north of Governor Swinton, the small islands south-west of Bentinck, some of the Marien group, islands south-west of Sir William James Islands and in a series of reefs along the east coast of St. Matthew's. In this last case, there are granite boulders, some as much as six feet long, well water-worn, and resting irregularly in a matrix of limestone sands, forming a granite-limestone conglomerate. Subsequent upheaval has given the whole a much crumpled and schistose appearance.

Similar deposits were met with in the Tavoy district in the Hindu

and Gt. Tenasserim rivers ; and there are somewhat similar occurrences in the vicinity of the Tavoy river.

46. No rocks were discovered that could be safely attributed to this group. The limestones forming the Elephant group and also those on the south-east of St. Matthew's Islands being probably older than the adjacent slates and conglomerates. They are very crystalline and apparently unfossiliferous.

47. There still remain three younger deposits which cannot be classed as one, and yet are probably of about the same age. Between them they cover quite a considerable area of the low flat islands, mentioned in group 6 of the granites, and also some of the islands on the south, the swamps and parts of the mainland. They are laterite, a partly cemented boulder-breccia and lithomarge.

They are all shallow, the laterite being seldom thicker than 14 feet, the conglomerates even less, and the lithomarge seldom over 60 feet. They all appear near granite and overlie them and the adjacent slates, schists, etc., of the older Mergui series.

The laterites and the conglomerates are often found associated, as also the laterites and the lithomarges in the more southern parts of the archipelago.

The laterites on Koolagyun and some of the adjacent islands are sufficiently rich in iron to be used as an ore.

The conglomerates when near water often present a deceptive lateritic appearance. In Tavoy district the cementing material of the conglomerate often carries a little gold.

The lithomarges in the vicinity of Yengan-Bokpyin often cover workable tin-bearing gravels, and were probably derived from the older slates, schists, and some of the felspar of the granites. The mottled appearance (red to blue) being due to the oxidation of iron derived from the dark mica, the tourmaline and the magnetite of the granites. The islands, Pumpkin, Pig, the Gregories, Carnac, Collins, Jenkins, etc., all furnish examples of these three younger deposits.

48. Split, crushed and otherwise disturbed rocks, which indicate pressure applied in an east and west direction, are abundantly evident. Nearly all the small islands, composed of sandstones show their strata up on end, and only in the larger islands, *e.g.*, Bentinck, are dips as low as 30° found. The slates are nearly always crushed and penetrated by quartz veins,

and in the case of Hayes Island there are two distinct folds roughly at right angles to one another. Owing to the numerous granite and quartz-porphry intrusions, it is rather difficult to delineate the principal lines of disturbance through the district, as separate from purely local disturbances.

49. Cassiterite is found in gravels on King's, Kissering and Davies Islands. On the first named it has been worked. Kissering is the best of the three and is worth prospecting, the cassiterite occurring within six feet of the surface. The tin on Davies Island, to judge by the places tested in the stream which enters the sea near the south-east corner of the island, would not pay to work. All the granite of sub-group 2 is worth prospecting for cassiterite. Although quartz lodes were frequently found, none carried visible minerals of economic value.

50. Gold is found on Horsborough Island and has been worked. It occurs as small flakes in gravels at comparatively shallow depths. On Russel Island there is a series of pyritic veins a little above sea-level which yield 10 dwts. gold on assay. These veins are crossed by several quartz stringers.

51. The only galena met with was on the west coast of Maingay's Island and this has already been reported on. Various laterites would furnish a certain amount of iron-ore were there a local demand.

52. At the end of March Mr. Page proceeded to the Tavoy district. In this district tin-mining was found to be at a standstill.

The following localities in which stream washing is carried on during the monsoons were visited :

- (a) Maungmeshaung river.
- (b) Ongbingwin.
- (c) The Hindu river and its tributary streams, including the Hinda river.
- (d) Old workings in the vicinity of the granites near Wagon, and about the village of Pagayé.

The results of investigation hold out no great hopes of the future of a tin industry in this district.

The following is a more detailed description of these localities.

- (a) *Maungmeshaung*.—In this area washing is carried on also by the most primitive methods. Even ground sluicing is apparently

unknown to the villagers engaged. The cassiterite is derived from the granites as well as from quartz veins at the slate-granite junction. Boulders of each of these rocks carrying cassiterite are to be found in the stream. Apparently two concentrations have taken place, one in which the cassiterite was concentrated on a thin clay layer on the denuded slates, whence they were washed by the present stream. The gravels are irregular, and the concentrated cassiterite will only pay to wash at intervals. European prospectors will find it more profitable to search for lodes in this locality than to work the gravels.

Wolfram is associated with the cassiterite, and occurs in rather large irregular segregations and thin veins in larger quartz veins in the slates.

- (b) *Ongbingwin*.—At this place the cassiterite occurs in quartz veins; the widest cassiterite-bearing vein found was only 12 inches thick. Cassiterite also occurs in small quartz stringers which have penetrated the sandstones near the granites in directions which cause the sandstones to split in irregular rhomboidal masses. It is probable that most of the cassiterite found in the gravels about the base of the Kehdaung is derived from this source. For a long time to come cassiterite will be concentrated in the streams during the monsoon in quantities that will pay to work. Whether it would pay a company to attack the hill on a large scale is extremely doubtful.

The natives are able to work the gravels only down to about 6 feet, and from one or two who worked with European prospectors, provided with pumps, it was ascertained that the concentrate proper is some 30 feet below the present surface.

In this locality and along the east shore of the Heinza Basin, tin-stone, wolfram, and gold are found. The auriferous specimens collected have not yet been assayed.

- (c) *The Hindu river and its tributaries* drain a portion of the central range east of Wagon. The Hindu enters the Khamaungthway, and the Hinda the Bean river, each tributaries of the Great Tenasserim. Cassiterite, in quantities that should be payable, exists within a few feet of the surface, and in the valley of the Hindu, gold is found with the tin concentrate. The Golden stream is perhaps the richest known locality, but very little has

been done in exploring to depths over 8 feet. The streams for 15 miles to the north of the Hindu carry gold, but in no case were values obtained that would appear to make it worth while to mine the gravels. From evidence obtained from boulders there is a strong probability of a quartz lode existing between the Hinda and Hindu. The boulders discovered carry tin in payable proportion, and indicate that the lode is at least 30 inches wide. This lode will cross streams which are already leased for lampan workings.

- (d) At the base of the *granite hills near Wagon* and north of the road there are old workings, and in isolated patches cassiterite, sufficiently concentrated to be worth washing on a small scale, may be found. This locality is approximately south-south-east of the tin-workings on the Maungmeshaung stream. There is a possibility of lodes being found, but pits will be necessary. At Pagayé there are tin-bearing gravels, which are, however, worked out. Some wolfram remains, and was traced to its source in quartz veins some 3 miles up the Sanché stream, a tributary of the Panuk Tein. Here there is a series of almost vertical quartz reefs varying from 30 inches to an inch or two in thickness. Only one of some 50 veins carried wolfram, but this was very rich, the wolfram forming a very large percentage of the lode, which was 14 inches wide.

The quartz veins occur in slate of the Mergui series which is partly metamorphosed to schist. This locality gives promise of future success to the prospector.

Besides visiting the above localities a tour was made from the Tavoy river, in a general south-easterly direction to near Mount Myinmolet-kat and down the Bean river to Myitta. The structure of this region is much the same as that of the archipelago. There are numerous gravel areas which looked as if they might contain cassiterite, but testing them in stream cuttings even down to 14 feet proved unsuccessful.

In the month of November a tour was made across the country from the Tavoy to the coast and along the granite hills to the Heinze Basin. All the high land is granitic, and there are large flats covered by the disintegrated granite sands. Floods prevented panning in the streams, but from the general appearance of the country there should be gravels worth working as well as lode formations near the granites worth testing.

53. There is one geological feature prominent in the Myitta valley that is not met with in the archipelago, and that is a Tertiary deposit which can be traced

Tertiary strata.

almost 60 miles north and south, and is some 12 miles wide in parts.

It consists of a series of shales, which dip generally at angles less than 18° . They strike roughly N. and S. and rest unconformably on the denuded older rocks, which form the flanking hills. These shales have numerous plant and fish remains not yet determined. On the shales rest conglomerates, which to a large extent have been derived from granites, and in many places the appearance of the arkose is so deceptive that it exactly simulates a granite. In some localities these conglomerates and shales are interbedded. A sandstone bed is apparently associated with them, and fossil-wood has been discovered in the Ayu stream, a few miles north of Myitta.

GEOLOGICAL SURVEYS.

Baluchistan.

54. Dr. G. E. Pilgrim was engaged during the field season 1907-08 in a survey of the Bugti and Marri country in Baluchistan, paying special attention to the Upper Tertiary fresh water formations from which vertebrate and invertebrate fossils were obtained thirty years ago by Dr. W. T. Blanford and more recently by Major McConaghey, the latter collections being already described by Dr. Pilgrim in *Records, Vol. XXXVI, Part I.*

Dr. Blanford was compelled to limit his work in this area to a mere reconnaissance, and naturally his conclusions, published in *Memoirs, Vol. XX*, need a certain amount of revision after this more detailed examination of the ground, the most important changes being made in the Upper Tertiary fresh-water beds. Although in the northern portion of the area Dr. Blanford had recognised the existence of three distinct formations in the Upper Tertiary—Upper Nari, Lower Siwalik and Upper Siwalik—and had mapped them as far north as Dera Ghazi Khan, he did not recognise the Nari further south, and referred all the fossils there collected to the Lower Siwaliks.

Dr. Pilgrim, however, has found that the lower 1,000 feet of the formation, mapped as Lower Siwalik in the Bugti Hills by Dr. Blanford, is Nari, and is separated from the Lower Siwaliks by a marked unconformity. In the Nari occur anthracotheroid remains, *Aceratherium blanfordi*, and

the remarkable molluscan fauna described by Blanford, while the Lower Siwaliks have yielded *Dinotherium indicum*, *Mastodon angustidens* and *Mastodon pandionis*. Dr. Pilgrim has made from the Nari beds a large collection of bones and teeth, which he has partially examined and briefly described. Although the wealth of species is not great the fauna clearly indicates an Aquitanian age. With the *Rhinocerotidæ* anthracotheroids (and in especial the genus *Brachyodus*) dominate the fauna. Representatives of the genera *Dinotherium*, *Tetrabelodon*, *Macrotherium*, *Cephalgale*, *Amphicyon* and *Pterodon* occur. Full descriptions of these will appear later. At the base of the series there occurs fairly constantly and over a wide area a band of marine rocks containing characteristic Nari nummulites. The marine beds pass gradually upwards, through estuarine strata containing mammalian bones and oysters, into true river deposits. Lithologically these beds are similar to the Naris of Sind, and especially to those exposed at Bhagathoro, near Lehwar. The greater coarseness of the sandstones and the abundance of ferruginous matter renders them readily distinguishable from the Lower Siwaliks.

There is a close lithological resemblance between the Lower Siwaliks of Sind and those of Baluchistan, the most typical beds being certain concretionary conglomerates with clay pellets, and there is no doubt that the fossiliferous horizons in the two areas are identical.

The occurrence of *Tetrabelodon angustidens* fixes an Upper age limit for the Lower Siwaliks in the Sarmatian, while a consideration of their fauna, as compared on the one hand with the Nari and on the other with the Middle Siwaliks of the Potwar in the Punjab, inclines Dr. Pilgrim to think that they are most probably of Tortonian age.

The Middle Siwaliks were not found in the Bugti and Marri hills, the characteristic Upper Siwalik brown sands and clays, conglomerates and boulder beds resting unconformably either on the Lower Siwaliks or on the Nari.

55. Post Tertiary deposits, differing but little in appearance from the Upper Siwaliks, but horizontally bedded and often resting unconformably on the latter, were seen in many places. Dr. Pilgrim considers that many of them like the older portion of the Indus alluvium, are of Pleistocene age.

56. The division between the Lower Tertiary Kirthar and Laki series was recognised and marked on the map, which also covers a small area of the Cretaceous formations which, a little further north, have furnished the well known Mazar Drik collections.

Central India and Rajputana.

57. In the last General Report the hope was expressed that the **Linking up with older work to north and north-west.** then ensuing season would witness the linking up of the work with that completed many years ago to the north and north-west by Messrs. Hacket and Kishen Singh.¹ To a certain degree this has been realised: at several points the new survey has come into touch with the old one, so that the early months of the current season should see the junction complete. The junction is, however, a superficial and provisional one only; there still remains the difficult and delicate task of accommodation and revision along the boundary between the old and the new, and this may further necessitate revision of parts within the old surveyed tract, which has only been very generally described by Mr. Hacket (*loc. cit.*) In that paper, also the various sub-divisions of the Vindhyan system (including the Lower Vindhyan shales and the Kaimur, Rewah and Bhandar series) are described as having been recognised, whilst the large-scale maps contemporaneously produced represent these same sub-divisions with the utmost nicety—although no convincing reasons are given for correlating them thus minutely with their supposed far-distant eastern equivalents, from which in fact their outcrops are separated by enormous areas of obliterating Deccan Trap and alluvium. With no fossils to guide and with discontinuous outcrops, the arbitrary splitting up of them in this western area to accord categorically with the divisions in the typical eastern area appears unwarranted, as it may also be very misleading.

The Central India party has already been compelled to make use of one tentative grouping of the Vindhyan in the neighbourhood of Bhopal, a grouping which has only with some reserve been proved to hold across the intervening area between it and the typical region; whilst for detached outlying masses separated from the main outcrops by many miles and buried in a sea of trap it was occasionally found necessary to be content with marking the outcrops simply as "Upper Vindhyan." In conformity with this caution, and from what has been already seen of these western representatives of the Vindhyan near Rampura and Neemuch, we are at present unprepared to accept without further enquiry the sub-divisions originally given them by Mr. Hacket.

¹ Mapped on the 1"=1 mile scale and briefly reported on, *Rec., Geol. Surv. Ind., Vol. XIV, Part 4, p. 279* (1881).

58. The work done last season includes the completion of sheets 211 (already begun in the preceding season) and

Area surveyed.

210. Sheets 239, 240, 241, 271, 272 and 273 were also completed with the exception of the portions of Gwalior State within them. Sheets 177, 178, 208, 209, 238, and 270 were partially surveyed. The area embraces portions of Rutlam and Sailana, Banswara, Partabgarh, Jaora, Sitamau, Dewas and Indore.

59. The Aravalli series, already touched for the first time during the previous season, were again further explored

Aravalli series.

along the westward margins of the Deccan Trap, but even this further acquaintance with them is not yet sufficient to warrant any generalisations of importance. A number of highly inclined bands of different rock types, all having a metamorphic or crystalline character and striking roughly north-north-west—south-south-east or north-west—south-east build up a sort of platform at the 900 feet level, on which the horizontal layers of Deccan Trap come to an end in their westward extension as fringing scarps or as detached outliers. In the Progress Reports sent in by Mr. Middlemiss and Mr. Heron much detailed information is given regarding the slates, phyllites, schistose conglomerates, mica-schists, quartzites, horn-blende-schists, crystalline limestone bands and the curiously related limonite-quartzose or cherty bands with in some cases grünerite, mixed gneisses, granitic gneiss, porphyritic hornblende syenite-gneiss and acid pegmatites, etc., but with the exception of a provisional attempt to map some of the crystalline limestone and ferruginous cherty layers which build a set of rocky ridges following the usual strike, no endeavour has yet been made to separate the series as a whole according to age or mode of origin. Having only so far been seen in the bottoms of the valleys cut out among the trap plateau, or in the vicinity of its western margin, it seems premature to attempt any such comprehensive classification for the present. Among such difficult rocks it will be necessary to proceed slowly and with caution, for some time to come. Nevertheless there is but little doubt that the rock series here called Aravalli represent the series of the same name as defined by Hacket, at least in the main; but whether any of the quartzites should be separately grouped with the much younger Alwar or Delhi series which along certain lines in the Aravalli range has been described by Hacket as caught up in folds among the older Aravalli schists, it is impossible to say. It is equally uncertain whether or not

the mixed gneisses are the equivalents of those referred to as "gneiss" by Hacket and coloured separately by him on his maps. Mr. La Touche in his more recent survey of Western Rajputana (*Mem., Geol. Surv., Ind., Vol. XXXV, Part I, p. 6*), found the rocks west of the Aravalli range, marked "gneiss" by Hacket, to be granites of two distinct ages, namely, the Erinpura and Siwana granites, differing widely in texture and composition. It seems quite likely, from what has already been seen during the past season, that there may well be exposed in this region both ancient Archæan gneisses and later eruptive plutonic masses.

60. Standing apart from the quartzites enfolded among the crystalline schists, and outcropping at much higher elevations among the Deccan Trap plateau to the east-north-east of Partabgarh town, occur a set of nearly horizontal quartzites or quartzitic sandstones and siliceous shales forming bare scarped hills. They represent one of the points of actual junction between the present and the old surveys, having been identified by Hacket and marked on his published map as the southernmost extension of his Delhi series. The same rocks are stated by that author to be overlaid unconformably to the north beyond Neemuch by the shaly series which he marks as Lower Vindhyan. The former were examined by Mr. Middlemiss' party, but the question of their relation to Hacket's Lower Vindhyan was not then gone into, and remains one of those that must be taken up immediately for important stratigraphical reasons. The first of these reasons is connected with the general doubts which have already been alluded to concerning the strict applicability of the sub-divisional scheme adopted by Hacket for his Vindhyan system. The second reason is that two earlier observers, Medlicott and Mallet, each referred the so-called Delhi quartzites to the Vindhyan system in the first instance, although the former afterwards expressed himself as satisfied with Hacket's relegation of them to the much lower Delhi series (see *Rec., Geol. Surv. Ind., Vol. XV, Annual Report, p. 3*). The impression now obtained of these strata is in favour of the earlier view, or at least that there is not sufficient difference between them and the Rampura scarp of Hacket's Kaimur to place them in separate systems. They are found to be not very strongly altered, the original rounded grains, the pebbles and other evidence of a sedimentary origin being quite appreciable to the naked eye.

Quasi-organic remains.

In some yellowish or pinkish siliceous shales locally becoming calcareous, which lie beneath

the coarser quartzose rock, some very obscure leaf like impressions were noted and some markings, including rows of pittings of very much the same nature as those described and figured by Mr. Vredenburg (*Rec., Geol. Surv. Ind., Vol. XXXVI, Part 4, p. 241*) from the Pab and Vindhyan sandstones of other localities. None of these shales show any mineralisation or foliation. Whatever be the final judgment as to the age of these beds, it is quite clear that they can have nothing in common with the phyllites and other schistose rocks found in the lower zone of so-called Aravallis as just described further west below the crest of the Deccan Trap plateau.

61. The next point where this survey touched the old mapped area is near Kukresor and Rampura in northern Indore, where Hacket's and Kishen Singh's Lower Vindhyan (or Suket) shales and Kaimur quartzite scarp occur. These rocks were examined by Messrs. Middlemiss and Jones, and they exhibit the shales everywhere in conjunction with the Deccan Trap plateau to the south; so that it was impossible to know what came immediately below them. Mr. Jones has made a careful study of these two formations and filled in the gaps in the mapping left over by the earlier survey. His Progress Report is amply illustrated by photographs and drawings.

The shales may be concisely described as being much softer than those below the Delhi quartzite. They are also generally much more fissile, breaking up into little cakes, not into splinters. Their colours vary from a drab or buff on the lower slopes of the scarps to darker and sometimes chocolate, purple and green tints in the lower river-bed sections. They are so soft and fragile that one can hardly make a specimen of them. Glauconite-bearing bands occur high up under the quartzitic scarp, and harder, micaceous, flaggy beds and free-stones (much used for building purposes) occur at lower horizons, with some rare calcareous beds, showing 300 feet at least, the base not being attainable. They lie practically horizontally but with small, sudden warpings and puckerings. There are no traces of porcellanic beds (compact fine ash, see *Mem., Geol. Surv. of Ind., Vol. XXXI, Part I, p. 93*) which in the Son valley sections characterise the Lower Vindhyan, and there are also no important limestones to correspond with the Rhotas and other limestones of the typical Lower Vindhyan area.

62. It may well be that the survey of this area may best be signalised by the finding by Messrs. Middlemiss and Jones of some very minute organic bodies

Fossils.

in these shales. Mr. Jones, who subsequently examined them more carefully in Calcutta, describes them as small concentrically wrinkled discs of carbonised chitinous substance, and he thinks it not impossible that they may represent the genus *Obotella* or *Chuarsa circularis*, described by C. D. Walcott from Pre-Cambrian rocks of Arizona¹ or possibly the operculum of *Hyolithellus*.²

63. The quartzite scarp which follows above these shales is a very striking formation, building a wall-like rampart, and stretching as far as the eye can see. It is a quartzite rather than a sandstone, not unlike some of the Delhi quartzite just described, but without being identical in any particular. It breaks with roughly conchoidal fracture and may be trimmed into good rough blocks, suitable for building purposes, but it cannot be got out in slabs like the typical Kaimur.

64. A curious set of rather small outliers of this quartzite occur generally some way south of the main scarp and at a much lower elevation, lying on the Suket shales not far from the Deccan Trap boundary. These outliers, according as they approach the Deccan Trap boundary more nearly, become of the nature of isolated crags or blocks arranged in clusters on the summit of gentle rises in the shales. An enormous number have been mapped by Kishen Singh, but many more would require delineation. Their most remarkable feature is their disturbed dips near the edge of the trap plain. The disturbance is not uniform. From block to block, separated perhaps only by a few feet, the dips vary widely in amount and direction. The whole at first sight presents an appearance of chaos. A number of these were plotted on a large scale by Messrs. Middlemiss and Jones.

65. Lametas were found at one place only by Mr. Heron on sheet 214, forming an irregular horizontal shelf, unconformable on the metamorphics. The bed is 10 feet thick and composed of impure, pale-purple limestone with grains and pebbles of quartz.

66. The great spreads of Deccan Trap (with its occasional intertrap-peans and cappings of laterite) was naturally met with over very large areas surveyed during the season. Its characteristics remain much as

¹ Bull. Geol. Soc. of America, Vol. X, p. 234 (1899).

² Bull. Geol. Soc. of U. S., Vol. IV, p. 141 (1886), with Pl. XIV, fig. 2 c.

before, and a number of separate studies of individual occurrences have been made and submitted in the reports by Messrs. Jones and Heron, with numerous sections and photographs in illustration of the chief fact. Intertrappeans were met with principally in parts of north-west Jhalawar and thin bands of clay were also noticed at a few places. Laterite occurs largely as cappings to small hills, principally in the States of Jhalawar, Rampura and Sitamau, with occasional masses of residual blocks and lateritic gravel. In some cases Mr. Jones has described rock dwellings cut out of the laterite, and rock temples, such as the Dhamnar cave temples, where the laterite is about 60 feet thick.

67. With reference to remarks made in a previous General Report (*Rec., Geol. Surv. of Ind., Vol. XXXIII, Part 2, p. 108*) on the subject of the almost universal absence of recognisable outliers of trap on Vindhya's, it may also be noted that in the area surveyed last season the same peculiarities are equally prominent. It is almost impossible ever to find a denuded natural section cut out of trap and showing Vindhya's below. But the case is entirely different as regards the behaviour of the trap to the Aravallis. In this case the usual position at the margins is to find the former as outliers capping hills of steeply-dipping schists, or running out as a sheeting on long spurs from the main plateau. An explanation of this anomaly is still wanting, but the theory advanced by Mr. Middlemiss that local extrusion with fissure eruptions may sometimes explain the extraordinary positions of the trap to the Vindhya's seems to be supported by what has been written above regarding the detached blocks of Kaimur sandstone on the Suket shales near the trap margin. We might understand it on the assumption that large sections of the Vindhyan country subsided *en masse*, with a corresponding welling up of the molten trap to some level of equilibrium. The margins in such a case would be liable to much disturbance, slipping and disintegration. In this connection it may be noted that the only place where the Delhi series near Partabgarh show steep dips is just at their junction with the trap south-west of Malhargarh, where they suddenly curve over to a vertical position.

Central Provinces.

68. The work in the Central Provinces was directed as before with a view to filling in the gaps in the general geological map. Mr. P. N. Datta spent the whole season mapping previously unsurveyed ground in the Chanda district. A small portion of this district in the neighbourhood of

Brahmapuri ($20^{\circ} 35'$; $79^{\circ} 55'$) had been examined towards the close of the previous season (1906-07), and survey work was, therefore, extended from this point eastwards, south-eastwards and southwards.

The larger portion of the area examined was found to be occupied by Archæan crystalline rocks; but Mr. Datta also mapped exposures of sandstones referred with hesitation to the Vindhyan system in some cases, and with doubt to the Gondwanas in others, as well as quartzites of probably Vindhyan age. Among the schists there are exposures of rocks resembling the typical Dharwars. A band of these, traced during the previous season as far as the latitude of Munjewara ($20^{\circ} 30'$; $80^{\circ} 8'$) was followed to its termination at Wyragarh ($20^{\circ} 26'$; $80^{\circ} 9'$). In the northern parts of this band, which lies partly in Bhandara and partly in Chanda, the rock varies from micaceous schist to argillite which shows little signs of alteration. Near Wyragarh these rocks strike roughly north-west to south-east and stand at a high angle. The general mass of crystalline rocks include ordinary gneiss, hornblende schist and mica-schist with occasional quartzitic rocks. These rocks occupy the lower levels, and are consequently covered by a mantle of cultivated soil, which effectually hides large areas. The eastern half of the area surveyed is occupied by rocks of a distinctly granitic character, the granites sometimes being porphyritic. Outcrops of quartz rock form prominent hills, the general geological character being not unlike that of the typical Bundelkhand areas.

Mr. Datta has drawn attention to the iron-ore deposits near Lohara ($20^{\circ} 24'$; $79^{\circ} 46'$) in the Chanda district which were described by the late T. W. H. Hughes in 1873,¹ and to some other smaller occurrences of hematites. These are rich in iron, but were considered by Messrs. Tata Sons & Company to be insufficient in quantity to support any large industry conducted on a modern scale. The only other materials recorded as of possible economic value are the building stones of various kinds obtainable from the sandstones, crystalline rocks and laterite.

Kashmir.

69. The remarkably interesting discoveries in Kashmir bearing on the age of the Lower Gondwanas have been described in previous Reports.² During the past year Mr. C. S. Middlemiss added very materially to the

¹ *Rec. Geol. Surv. Ind.* Vol. VI, 77.

² General Reports for 1902-03, 1903-04 and 1906. See also H. H. Hayden, *Rec. Geol. Surv. Ind.* Vol. XXXVI, pp. 23-39, 1907.

value of these discoveries by his unexpected find of a more complete and richly fossiliferous section in the Golabgarh pass, on his march from Jammu across the Pir Panjal range into Kashmir.

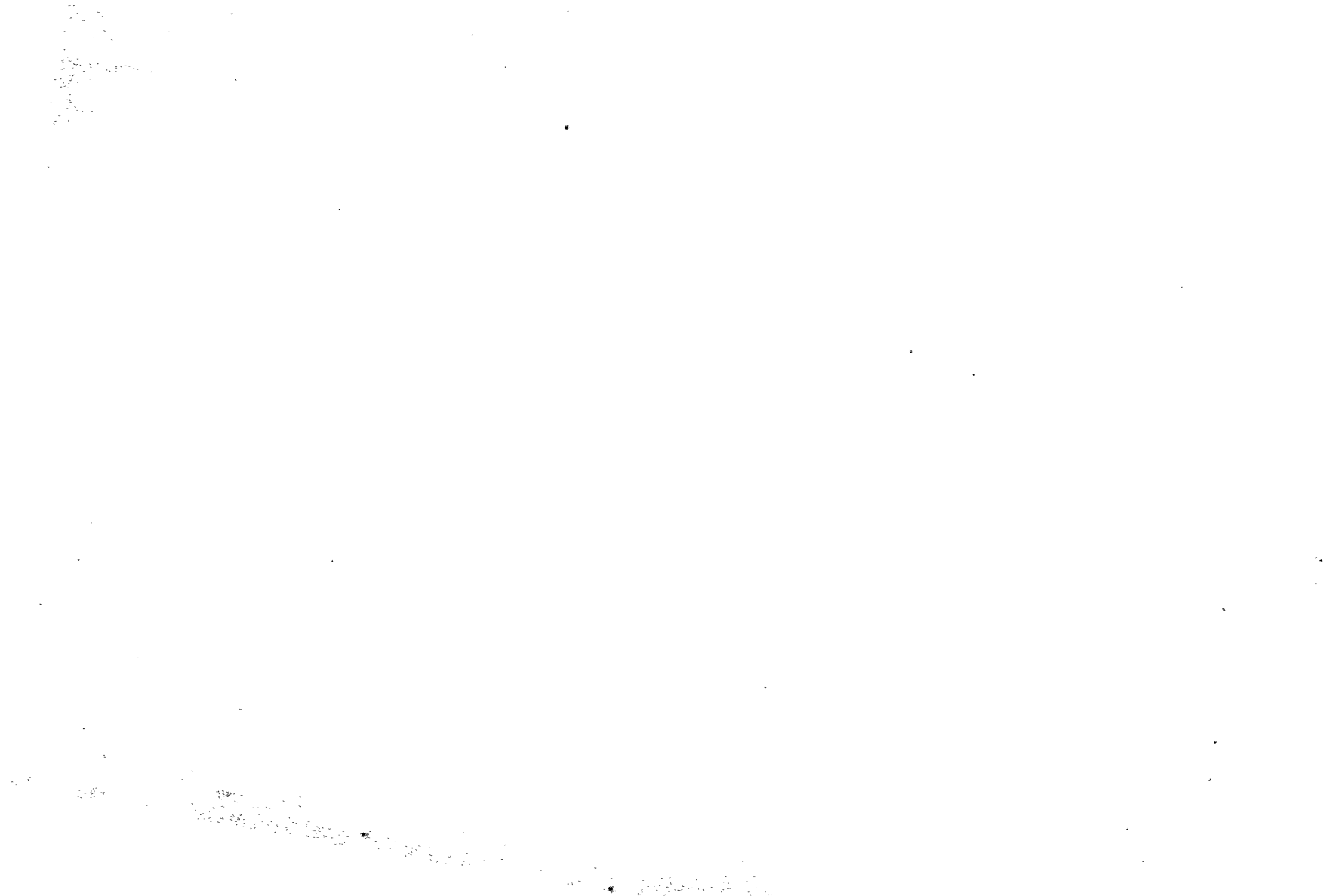
In this section Mr. Middlemiss found clearly displayed in a closely-folded syncline resting on the Panjal volcanic series :—

- (i) Limestones, without recognisable fossils, corresponding in character and position to the Triassic limestones of other sections ;
- (h) Black shales with *Spirifer Rajah*, 10 to 20 feet thick ;
- (g) Earthy, micaceous sandstones with *Marginifera*, 300 feet thick ;
- (f) Black shales, thin bed ;
- (e) *Protoretepora* limestones, 200 feet thick with abundant fossils ;
- (d) Earthy and (above) calcareous sandstones ;
- (c) Sandstones and carbonaceous shales, with Lower Gondwana plants, 400 feet thick ;
- (b) Siliceous and carbonaceous shales, 180 feet thick ;
- (a) Basal conglomerate, 6 feet thick.

These beds form an apparently conformable series, from the basal conglomerate resting on the Panjal volcanics up to the limestone of probably Triassic age. The chief interests are centred in the beds (c), as in these beds Mr. Middlemiss found, in addition to *Gangamopteris* previously recognised in the Kashmir valley sections, two or three species of *Glossopteris*, with the supposed rhizome *Vertebraria indica*, and groups of leaves resembling those of *Psymophyllum*. The *Glossopteris* remains were found in the higher beds of the series, and the order is that of the lowermost Gondwanas of the Peninsula—the Talchirs and the lowermost of the coal-bearing series, distinguished as the Karharbari beds.

Mr. Middlemiss re-examined several previously described sections of the Zewan beds and associated strata in the Kashmir valley and demonstrated beyond doubt that the Lower Trias, formerly thought not to exist in Kashmir, is present and is richly fossiliferous in places. The results of these observations are described with characteristic clearness and charm in a special paper.¹

¹ C. S. Middlemiss, *Rec. Geol. Surv. Ind.*, Vol. XXXVII, Part 4.



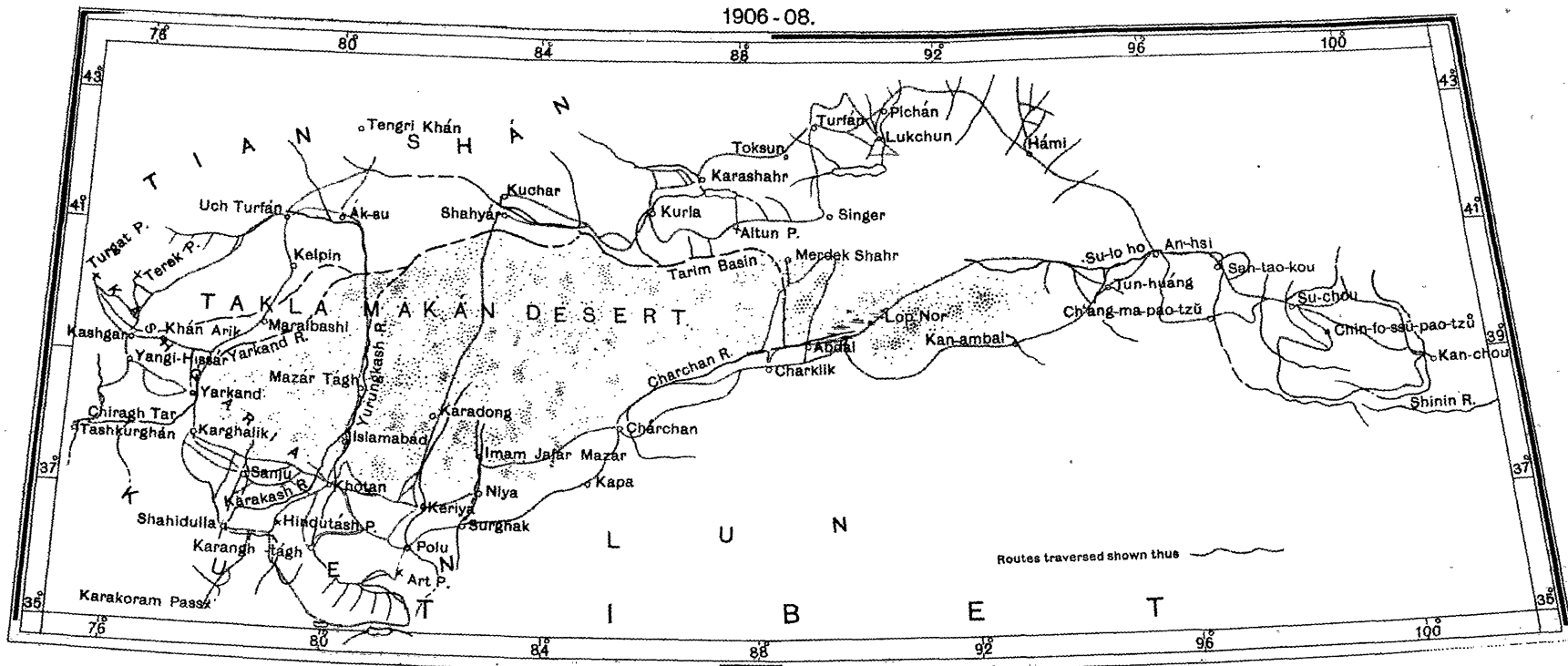
EXPLORATIONS IN CHINESE TURKISTAN & KANSU

BY

Dr. M. A. STEIN AND SURVEYORS RAM SINGH & LAL SINGH

in

1906-08.



*Heliostereographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dûn.
December 1909.*

REPORT ON GEOGRAPHY AND GEODESY.

BY

CAPTAIN H. H. TURNER, R.E.**EXPLORATIONS IN CENTRAL ASIA.**

The close of the year 1908 witnessed the return of two distinguished explorers, Dr. Sven Hedin from Tibet and Dr. M. A. Stein from Chinese Turkistan and Kansu.

Dr. Sven Hedin started from Leh on the 12th August 1906 and made two complete journeys across the greater part of Tibet. He crossed in a south-easterly direction the great mountain ranges and overcame by his indomitable courage all obstacles. When, owing to the opposition of the Tibetans, he was prevented from returning from Shi-ga-tse by a northerly route, he made his way back to Leh, thence again set out on his second journey and worked his way south in order to obtain a better knowledge of the great range of mountains north of the Brahmaputra.

Dr. M. A. Stein in addition to obtaining rich stores of archæological treasures has contributed largely to our geographical knowledge of Chinese Turkistan and Kansu. He was accompanied in the earlier part of his journey by Rai Sahib Ram Singh and on the latter portion by Rai Bahadur Lal Singh. Both these men, surveyors of the Survey of India, are experienced explorers; with their assistance Dr. Stein was enabled to bring back detail surveys of much of the country.

Dr. Stein started from Chitral in the spring of 1906, crossed the Baroghil and Wakhjir passes to Kashgar; thence, taking an easterly direction, he skirted the southern edge of the great Tarim basin and passing through Western and Central Nanshan, arrived at his most easterly point Kan-Chou in August 1907.

In passing from the great Tarim basin to the higher level of Kansu the route followed a well-marked depression, which gradually narrowed into a regular valley descending from the north-east and water was easily obtained by digging wells. Dr. Stein considers that the presence of this valley indicates that the waters of the Su-Lo Ho and Tun-Huang rivers at

one time made their way down to Lop-Nor. This would make the original eastern limit of the great Tarim basin extend as far as meridian 99° , that is 7 degrees beyond its present limit. Beyond this valley the expedition came to a wide basin enclosed on the north by the Kuruk Tagh range and to the south by ranges of dunes; within the basin were a succession of dry lake beds with high clay terraces between and around them. The lake shown on the map as Kara-Nor, where the Su-Lo Ho and Tun-Huang rivers were believed to end lay still more than a degree to the east, yet this was the only source from which the great basin could be filled. It was discovered later that a considerable river flows out of the Kara-Nor during the spring and summer floods and, after draining a series of small lakes and marshes, carries its waters through to these lake beds.

The return journey was commenced from Kan-Chou early in September 1907. From An-Hsi the expedition made its way across a stony desert *viâ* Hami along the southern slopes of the Tian Shan range to Turfan, from thence it passed through Karashahr to Kurla and along the northern edge of the Tarim basin to Kuchar. The expedition then struck across the Takla Makan desert to Keriya; this journey was nearly leading to fatal consequences; before the party reached the point where the Keriya river dies away in the sandy desert the water supply was almost exhausted and the ration for some days had been only one pint per diem a man. The Keriya river was found to have formed a new bed a considerable distance to the west of the one given by Hedin. From Khotan the desert was recrossed to Ak-su *viâ* the Khotan river. Thence the expedition again returned to Khotan *viâ* Yarkand and, after some final surveys in the Kuen Lun range, made its way over the Karakoram range to Leh. It was in carrying out this last survey work that Dr. Stein had the misfortune to get his feet frost bitten. After undergoing an operation at Leh, he was enabled to continue his journey, finally reaching India in December 1908. Dr. Stein, in spite of his anxiety to reach England and the pain that he was still suffering from the effects of his operation, did not leave India until he had personally brought the services of his energetic Surveyor-Assistants to the notice of the Government of India and secured them ample rewards for their labours. This recognition of his assistants' work is much appreciated not only by the surveyors themselves, but by the Surveyor-General and other members of the Survey of India. Dr. Stein has now recovered the use of his foot and it may be hoped will be able to carry out further exploration work in the future.

Dr. Stein's own route between Mastuj and Leh amounted to a total distance of some 6,500 miles. The route has been mapped throughout by plane table traverse either by Dr. Stein himself or by one of his survey assistants and in addition the following detail surveys have been made:—

Rai Sahib Ram Singh commenced with a survey of the eastern slopes of the Muztagh Ata peak and of the head waters of the rivers between Tashkurghan and Yangi Hissar continuing it from Kizil Bazar to Kok-Yar.

He then obtained a survey of the Karakash river to Sumgal above Shahidulla and the watershed between that river and the Yurungkash. He crossed the Kuen Lun by the Hindutash pass, and made a connection with the work of 1900.

Dr. Stein and Ram Singh then carried out a joint survey of the Nissa Valley in the Kuen Lun range and made an unsuccessful attempt to reach the head waters of the Yurungkash river from the west. Dr. Stein noticed the fact that old moraines in this valley could be traced 3 miles below the present foot of the Kash-Kul glacier.

From Khotan Ram Singh surveyed along the northern slopes of the Kuen Lun and Altyn Tagh ranges as far as Charklik, including a triangulation which he connected with points of Captain Deasy's survey, a most valuable piece of work. On his return journey he continued this survey from Tun-Huang back to Charklik.

In travelling eastward from Tun-Huang Dr. Stein and Ram Singh surveyed the watershed between the Su-Lo Ho and the Tun-Huang rivers in Western Nanshan, then, passing to Central Nanshan, a survey was obtained of the northern mountains of that district. In all an area of 24,000 square miles was mapped between An-hsi and Kan-chou.

On the return journey at An-hsi, Rai Sahib Ram Singh was relieved by Rai Bahadur Lal Singh and the latter obtained surveys in the neighbourhood of Hami and Turfan and of the portion of the Tian Shan range, which lies to the north of these places. He was then employed on a survey of the Kuruk Tagh range from a point directly south of Turfan to Kurla and surveyed the range separating the Karashahr Valley from the Turkistan plains.

From Ak-su Rai Bahadur Lal Singh carried a continuous survey through the outer Tian Shan range as far as Kashgar, while Dr. Stein surveyed the route *via* the Uch-Turfan Valley to Kelpin and on to Yarkand.

Lal Singh then succeeded in mapping the only remaining unsurveyed portion of the northern slopes of the Kuen Lun range west of Khotan.

Finally on the return journey from Khotan to India Dr. Stein and Lal Singh obtained a survey of head waters of the Yurungkash river. A previous survey had demonstrated the impracticability of approaching from the west, the attempt was therefore made from the east, through the confined gorges above Polur to the northernmost high plateau adjoining the outer main Kuen Lun range. Here Dr. Stein obtained a guide and together with Lal Singh made his way through the Zailik valley, and ascended a series of high spurs of the main Kuen Lun range. By establishing survey stations close under the crest line of this range, which here rose to an average height of 20,000 feet, they were enabled to map with theodolite, planetable and photographic panoramas the greater portion of the grand mountain system containing the head waters of the Yurungkash. Thence they carried the survey along the southern slopes of the Kuen Lun over the Aksai Chin, which instead of being a continuous plain was found to consist of continuous snowy spurs with broad valleys between them. They at length struck the old route between Ladak and Khotan travelled by Mr. Johnson of the Survey of India in 1865, when he visited Haji Habibullah, chief of Khotan. This route was traced to the valley, which must have led up to the pass over the main Kuen Lun range, but the route became obliterated at the head of the valley. The explorers, in order to fix their position and link up with former surveys, climbed to a height of 20,000 feet on the watershed. Their descent was delayed till late in the afternoon and on return to his camp Dr. Stein discovered that his feet had been frost bitten.

In addition to the above surveys Dr. Stein has mapped the line of the existing great wall of Kansu and also the line of the old defensive wall. The first traces of this latter were found in the desert some five marches west of Tun-Huang and was followed as far as An-hsi, later its extension was traced from its junction with the present great wall at the Chia-yu Kuan gate back to An-hsi. This ancient wall, Dr. Stein considers, dates back to the second century B.C. So long as it runs parallel to the prevailing wind from the east and north-east its preservation is almost perfect; it is evident that the same conditions must have prevailed for the last 2,000 years. He gives a remarkable instance of the permanence of tracks in the gravel soil; all along the great wall he could trace the path of the sentries, who, two thousand years ago, had marched up and down their beat behind the wall. Dr. Stein mentions how the existence of this

defensive line brings out the important geographical fact, that the desert hill region north of the Su-Lo Ho marshes, now quite impracticable owing to the absence of water, must then still have been passable.

The following table shows the difference in position with that formerly accepted of some of the principal places visited by the expedition :—

	OLD VALUE OF OTHER EXPLORERS.		DR. STEIN'S NEW VALUE.		
	Latitude.	Longitude.	Latitude.	Longitude.	
	° ' "	° ' "	° ' "	° ' "	
Kashgar .	39 26 0	75 54 33	39 26 5	75 57 50	Latitude observation by Ram Singh.
Yarkand .	38 26 0	77 18 33	38 24 30	77 16 6	Ditto ditto.
Maralbashi .	39 46 0	78 43 33	39 46 25	78 25 19	Obtained by plane-table traverse.
Karadong .	38 32 0	81 47 33	38 32 29	81 54 15	Latitude observation by Ram Singh.
Charchan .	38 10 0	85 23 33	38 8 18	85 34 15	Ditto ditto.
Kuchar .	41 45 0	82 59 33	41 42 58	83 10 0	Lal Singh's Latitude observation.
Ak-su .	41 13 0	80 43 33	41 8 32	80 2 32	Obtained by 3 separate planetable traverses.
Charklik .	39 4 0	88 0 33	39 1 50	88 13 0	Ditto ditto.
Niya .	37 6 0	82 44 33	37 3 34	82 45 40	Fixed by triangulation by Ram Singh.
Khotan .	37 8 0	79 54 33	37 7 40	79 58 30	Latitude observation by Ram Singh.
Karashahr .	42 3 30	86 43 0	42 6 50	86 31 40	Obtained by plane-table traverse.

The Longitude of Keriya, obtained by Captain Deasy from chronometer observations, coincided with Rai Sahib Ram Singh's value, which was obtained by connecting Keriya by traverse with his Kuen Lun triangulation.

Dr. Stein's map consisting of 94 sheets is now being drawn at the Trigonometrical Survey Office, Dehra Dun, on the scale of 4 miles to the

inch. On completion of this map, which contains only the work of Dr. Stein and his assistants, the information obtained by him will be incorporated in the Survey of India Maps.

APPARATUS FOR MEASUREMENT OF GEODETIC BASES.

The Invar wire measuring apparatus, mentioned in last year's report as having been ordered from M. Carpentier of Paris, has been received. The wires have been standardised at the Bureau International des Poids et Mesures at Sèvres and the apparatus is complete in every detail.

In order that wires used for base measurements may be periodically tested, it is necessary to have a permanent base against which they can be checked. An alley 97 feet in length is now being constructed in the grounds of the Trigonometrical Survey Office at Dehra Dun, in which a base 24 metres long will be laid down. The base will consist of 7 isolated pillars, placed at intervals of 4 metres from centre to centre; on the face of each pillar a projecting brass plate will be embedded, on which will be engraved the referring mark for measurements. The intermediate pillars will be 2 feet square in section and the two end ones 3 feet by 2 feet the extra length being given to the end ones to enable lengths of 25 metres and 80 feet to be laid down.

The alley forms the south side of a building having pendulum and seismograph rooms on the north side. In order to keep the temperature of the alley as equable as possible, no windows will be placed in the south wall, lighting and ventilation will be obtained by raising the roof of the alley above that of the main building and putting in north lights.

The base will be laid out by means of the new 4 metre Invar standard bar now being manufactured at Geneva. In each of the end walls a frictionless pulley will be fixed, over which the wire to be tested will be strained.

Invar, although having a very small co-efficient of expansion, is subject to secular changes. These secular changes which take the form of a gradual shortening, decrease in magnitude as the alloy increases in age. The treatment, to which the wires are subjected at Sèvres, may be said to prematurely age the wires, that is, it hastens on these secular changes and the wires, when finally issued by the Bureau International, may be considered practically free from this drawback. They have probably never been used in the extremes of heat and cold to which they will be liable in measurements of base lines in countries such as Baluchistan and it will be necessary to watch their behaviour very closely.

Nine wires have been received from the maker. Of these, three wires will always remain at head-quarters being termed the standard wires and frequent comparisons will be made with them against the base. The remaining six wires will be taken into the field, three of them being used as field standards and the other three used for the actual measurement of the base.

METHOD OF CHECKING TRAVERSE WORK.

Where a topographical survey has to be carried over a large extent of flat country, secondary and tertiary triangulation, owing to its prohibitive cost, has to be dispensed with. In the plains of India Principal Triangulation, mostly along meridional lines, has been run at intervals varying from 40 to 120 miles apart; these were executed many years ago by building towers of 30 feet and over. The substitute for tertiary triangulation is a net work of traverses, but these need controlling at points at closer intervals than those given by the principal triangulation. The method proposed is to run accurate main traverses at suitable intervals, starting and closing, if possible, on principal triangulation series.

A trial has been made this year of running a main traverse by using wires in catenary for the linear measurements. M. Yaderin's apparatus, which was obtained some years ago, was utilised for the purpose; a slight alteration being made so as to enable the wires to be strained mechanically.

The first line run was about 80 miles in length; it started from Burala T. S., a principal station of the Jogitilla series, and was to have closed on the secondary station of Shorkot, unfortunately this was found to have been destroyed and could be only approximately located; the accuracy of the line could not therefore be tested. Starting from a point on the first line a second line, 41 miles in length, was run, a cheaper personnel being employed. In addition to checking traverses, it was executed for the purpose of locating the position of the secondary station of Dorewala, on which much of the traverse work in the Southern Punjab had closed.

The operators were quite new to the work and at first progress was slow but an average rate of about three miles a day was eventually obtained. This work was carried out with an 80-foot wire, the 160-foot wire being used only when the ground would not permit the use of the shorter wire; it would probably both facilitate and cheapen the work to use the

160-foot wire throughout. There is no doubt that a traverse run in this manner is unnecessarily accurate as a basis for traverse work and the cost even with the cheaper personnel is greatly in excess of other methods.

It has, however, been demonstrated that it is possible to run a long traverse line by these methods over approximately flat country. The great difficulty experienced seems to have been the placing of the trestles in the required position; this difficulty, however, can easily be obviated by either forward or backward tape measurements.

Throughout the length of the line levels were taken to each trestle and astronomical azimuths at intervals of about 11 miles.

A second and cheaper method of running sufficiently accurate main traverses is by measurements along the ground with a tape or crinoline chain starting and closing on fixed points. This was likewise tried one season, an aggregate length of 50 miles being measured. The result of this method gave an error of about one in eight thousand, a sufficient accuracy on which to base traverse work. This method will in all probability be largely utilised in future.

The great advantage that the wire in catenary possesses over this latter method is that, since the level staff is read on each tripod placed, the line gives fairly accurate heights at every wire interval.

Principal Triangulation.

During the year four detachments were employed on Principal Triangulation and in consequence the addition made to the Geodetic Survey of India has again been large. In all a length of 270 miles of triangulation covering an area of 9,600 square miles has been added.

The districts in which the detachments were working were :—

1. Northern Baluchistan.
2. Shan States (Burma).
3. Kashmir.

Northern Baluchistan.

In May 1908, Lieutenant Oakes commenced the Northern Baluchistan Series. He started from the base Zawa-Zibra of the Kalat Longitudinal Series and working along meridian $66^{\circ}30'$ carried the new series north-

wards to parallel 31° . From here onward the series will take an easterly direction, following as closely as possible the Afghan-Baluchistan frontier, eventually closing on the Great Indus Series.

Lieutenant Oakes completed a length of 100 miles of triangulation, which covers an area of 3,500 square miles. The 8 completed triangles have an average error of $0''\cdot41$. The side Koi Maran-Takatu of this series 68 miles in length is the longest side of the Indian triangulation.

An Astronomical Azimuth was observed at Mashelak H. S. (Lat. $30^{\circ}14'$ Long. $66^{\circ}47'$) and the difference found between the value so obtained and that computed from the triangulation was $1''\cdot25$: the sign of this difference was positive as are all values as yet obtained in Baluchistan. This shows that the triangulation in that region is trending south of its true direction. The work was greatly hindered by the thick dust haze and consequently this year it has been decided to work in the early autumn.

Mr. Tresham recommenced work in September 1909 at the point where Lieutenant Oakes left off.

In order to secure the early completion of the Northern Baluchistan Series and give points on which the Topographical Survey in North Baluchistan could adjust its minor triangulation, it was decided to carry on the work of the series simultaneously from both ends. In the autumn of 1908 Lieutenant Cardew was instructed to start the work from the eastern end from the side Umarmhel-Maidan of the Great Indus Series. The station at Maidan, however, was found to have been destroyed: this necessitated starting from the base Sakesar-Bani.

Lieutenant Cardew executed 50 miles of triangulation enclosing an area of 1,900 square miles. The seven completed triangles have an average triangular error of $0''\cdot548$. Owing to unforeseen difficulties having arisen, it is possible that the junction of the North Baluchistan Series with the Great Indus Series will have to be made further south in the neighbourhood of Dera Ghazi Khan.

An Astronomical Azimuth was observed at Umarmhel and the difference found between the value so obtained and that computed from the triangulation was $7''\cdot66$: the sign of the difference is positive. Lieutenant Cardew then ran a secondary series across the Bannu plain to pick up the junction of the tertiary triangulation of the Tochi and Kurram Valleys.

A comparison between the values obtained and those determined by Lieutenant Phillimore in 1904-05 of the three most important points are given in the table below :—

Name of Station.	LIEUT. CARDEW'S VALUES.		
	Latitude.	Longitude.	Height.
Pakkalota	32 58 19'045	70 25 28'936	3,151'2
Jinighar	33 10 35'637	70 40 12'762	3,989'4
Darweshtar Sar	33 09 41'933	70 20 00'459	5,056'2

Name of Station.	LIEUT. PHILLIMORE'S VALUES, 1904-05.		
	Latitude.	Longitude.	Height.
Pakkalota	32 58 18'95	70 25 29'01	3,169'3
Jinighar	33 10 35'48	70 40 12'70	3,997'7
Darweshtar Sar	33 09 41'48	70 20 0'56	5,073'1

The difference in Azimuth of Jinighar from Pakkalota amounts to 3".02.

Shan States, Burma.

In Burma Captain Browne continued the Great Salween Series: the new triangulation is 120 miles in length and encloses an area of 4,200 square miles. It consists of 9 triangles with an average triangular error 0".47.

By the extension of this series the Indian Arc of parallel has been increased to $38\frac{1}{2}$ degrees of Longitude, extending from Longitude $60^{\circ}54'$ on the western border of Baluchistan to Longitude $99^{\circ}24'$ on the eastern border of the Shan States.

An Astronomical Azimuth was observed at Klip Ma and the difference found between the value so obtained and that computed from the triangulation was 8".60, the sign of this difference was negative which is in accordance with the other values found in Burma.

In addition many of the stations of the Topographical Triangulation, then in progress in that locality, were fixed.

The work was much hindered by the continuance of heavy monsoon rains in November which prevented any work being done until the beginning of December, even then the heavy mist greatly interfered with the observations.

On the 2nd of March the dust haze became so thick that work had to be entirely stopped.

Kashmir.

In Kashmir Mr. de Graaff Hunter has started a new series, which emanates from the side Nerh-Khagriana of the North-West Himalaya Series. It is proposed to run this series north as far as Gilgit, it will then trend eastward and meet the old triangulation again on the side Marshala-Thalanka. From thence the old triangulation will probably be revised southwards and the series will finally close on the side Gurhagarh-Somnabanj of the North-West Himalaya Series. The old triangulation, a magnificent work carried out by Major Montgomerie, R.E., during the years 1855—63, with 14-inch Vernier theodolites, is not classed as principal work; it emanates from the side Gurhagarh-Somnabanj of the North-West Himalaya Series, runs northward to Skardu and thence up the Indus Valley to Leh, where it breaks up into three separate series none of which close on the Indian triangulation.

The present work will prove a formidable undertaking, many of the proposed stations being at altitudes of 16,000 feet and over, two at least are over 18,000. When completed the series will form the most northerly extension of the principal triangulation of the Great Trigonometrical Survey of India and the stations will far exceed in height those of any principal triangulation yet executed.

Mr. de Graaff Hunter commenced work in April of this year; after a break of two months during the rainy season he recommenced the work early in September.

Secondary Triangulation.

In addition to the principal triangulation reconnaissances were made and stations built for secondary series in Burma and Assam which will be observed in the coming field season.

Tidal Operations.

During the past year tidal registrations by automatic tide-gauges have been taken at the ports of Aden, Karachi, Apollo Bandar (Bombay),

Princes Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein and Port Blair. The registrations at these ports have been satisfactory.

At Moulmein a new observatory was erected in August 1908 on a site close to the old one which was dismantled in 1886. The tide-gauge was duly installed and registrations were commenced from the 1st of January 1909. The true zero of the gauge is identical with that adopted in 1880 when the gauge was first started. The results derived from the observations which are now being registered will serve as a check on the accuracy of the predictions already published.

Levelling Operations.

The total outturn of double levelling of precision completed during the field season of 1908-09 was 1,085 miles, in the course of which observations were taken at 13,223 stations. The bench-marks determined were 25 standard, 90 embedded, 623 inscribed, and 34 belonging to other departments. The heights of 3 Principal and 8 Secondary G. T. stations were also determined by levelling as a check on the heights deduced by triangulation.

During the field season the line of levels, which was commenced in season 1906-07 from Ferozepore with the object of breaking up the large level circuit Karachi-Ferozepore-Sironj and Bombay by direct levelling across Rajputana to Ahmedabad, has been completed, and the lines (1) Katni to Nagpur, and (2) Wardha to Hyderabad (Deccan), have also been completed.

Standard Bar Comparisons.

Comparisons of the Standard Bar A of the Indian Survey were made in 1907-08 with the secondary Standards IB and IS, preparatory to the sending of Bar A to Sévres for comparison with the International Metre. The reasons for this undertaking and the results deduced from the observations were communicated to the Board of Scientific Advice in the Report for 1907-08. Briefly, the results of the comparisons were :—

IS—A at $62^{\circ}\text{F} = 83.12$ millionths of a yard.

IB —A at $62^{\circ}\text{F} = 196.73$ millionths of a yard.

Length of Bar A at $62^{\circ}\text{F} = 3047.996$ millimetres.

On completion of the comparisons with the International Metre, Bar A was returned to Dehra Dun, where a second series of comparisons

was undertaken for the purpose of ascertaining whether the length of the Bar had undergone any change during the journey to Europe and back and in the event of an alteration of length having occurred, of determining the amount of the change. These comparisons were made in November and December 1908 at Dehra Dun. Twenty sets of comparisons were made of Bar A with each of the Secondary Bars IB and IS. In the case of Bars A and IS the temperatures during the comparisons ranged from $61^{\circ}2$ to $64^{\circ}9$ and during the comparison of A with IB from $57^{\circ}6$ to $65^{\circ}5$. The final results were—

IS—A at $62^{\circ}F = 81^{\circ}13$ millionths of a yard.

IB—A at $62^{\circ}F = 193^{\circ}38$ millionths of a yard.

A comparison of the values obtained before the journey to Sévres with those derived from the observations of December 1908 show that it is probable no change took place in the length of the Standard Bar A between the time of its departure from Dehra and its return from Sévres and that, therefore, reliance may be placed in the value of Bar A in terms of the International Metre given above.

Pendulum Operations.

One of the spheres of research to which pendulum determinations will be devoted is the investigation of the constitution of the earth's crust, a discussion which embraces the nature of mountain masses; whether these are merely incidents of the surface, affecting only the outer configuration or whether they are more important features producing by their weight inequalities of density in the underlying matter. About the middle of the nineteenth century, Archdeacon Pratt put forward the theory of compensation of the visible masses on the earth's surface. His theory was that as far as visible land masses are concerned, "in the land portions of the earth's surface there is a deficiency of matter below the sea level approximately equal to the amount of matter above it." Generally stated, his theory was that at all places the amount of matter contained in a vertical column in the earth's crust was the same. One of the aims of gravimetric research has been to ascertain to what extent this theory is correct, whether it holds good for all places, for all geological formations and for all heights above sea level and all degrees of relief of surface configuration.

The amount of compensation at any place is readily shown by a comparison of the actual intensity of gravity, as derived from observations

with the theoretical intensity deduced from established formulæ. This comparison will show by how much the force of gravity at any chosen place is in excess or defect of the theoretical value. Using this result in combination with the results of geological research, we shall be enabled, it is hoped, to learn something of the interior constitution of the earth's crust.

With this end in view gravity operations have been carried out in India, at points in the Himalayas, the Siwaliks, the Nilgiris, Baluchistan and in the submontane plains. During the winter of 1908-09 they were undertaken in western Central India, where, though the relief above the sea level is not so great, the amount of matter in the geological formations the Central Indian basalt overflows, is known to be excessive. The investigation has here embraced a somewhat different array of conditions to that prevailing in Himalayan regions. In the latter the research deals with the compensation of surface masses which have been caused by folding of the crust. In the former case, we are enquiring into the effect of overloading of the surface by the basalt overflows.

The data available at present is insufficient for formulating any theories of crustal structure and the operations at present being undertaken are directed to the acquisition of facts from localities exhibiting varied conditions, which facts will later enable us to enter into discussions bearing on the general theory of compensation and the extent to which its teachings are affected by local conditions.

The stations visited by No. 23 Party of the Survey of India during the season of 1908-09 were :—

- | | |
|--------------|--|
| UJJAIN . . . | on the gentle northern slope of the Vindhya hills,
in the middle of basalt region. |
| MHOW, | near the crest of the same hills, also on the basalt. |
| MUKHTIARA, | } in the Nerbudda valley, close to the line of divi-
sion of the basalt and the submetamorphic
formations. |
| MORTAKKA | |
| KHANDWA . . | in the middle of the trap area, between the Ner-
budda and the Tapti rivers. |
| ASIRGARH | on the crest of the Satpura hills, on trap beds. |
| JALGAON . . | in the Tapti valley, on the edge of the trap close
to the alluvial deposits of the Tapti valley. |

These seven stations are all in approximately Long. 76. .

AMRAOTI, } in the Berar plains south of the Satpuras, close
 ELLICHPUR } to the line of division between the trap and
 alluvium, the former on the trap, the latter on
 the alluvium.

BADNUR . . . in the central portion of the Satpura hill tracts,
 on the edge of the trap and metamorphic rocks.

SHAHPUR . . . a little to the north of Badnur, on beds of the
 Gondwana series.

Hoshangabad, in the Nerbudda valley, on the alluvium.

These stations are in Long. 78° approximately.

The results of the season's work are given in Table I.

Table I.

Station.	Latitude.	Height above M. S. L.	Observed value of gravity= g	g reduced to sea level = g_0	Theoretical value of gravity= y_0	$g_0 - y_0$
	° / "	Feet.	Dynes.	Dynes.	Dynes.	Dynes.
Ujjain . . .	23 11 0	1,612	978·677	978·771	978·802	— 0·031
Mhow . . .	22 33 10	1,903	978·620	978·730	978·763	— 0·033
Mukhtiarā . . .	22 23 40	926	978·664	978·718	978·753	— 0·035
Mortakka . . .	22 13 20	576	978·703	978·737	978·743	— 0·006
Khandwa . . .	21 49 30	1,014	978·692	978·752	978·714	+ 0·038
Asirgarh . . .	21 28 10	2,077	978·584	978·711	978·694	+ 0·017
Jalgaon . . .	21 0 0	760	978·633	978·677	978·665	+ 0·012
Amraoti . . .	20 55 50	1,123	978·609	978·675	978·665	+ 0·010
Ellichpur . . .	21 18 20	1,314	978·618	978·694	978·685	+ 0·009
Badnur . . .	21 54 10	2,103	978·607	978·730	978·724	+ 0·006
Shahpur . . .	22 11 30	1,284	978·663	978·738	978·743	— 0·005
Hoshangabad . . .	22 45 0	1,002	978·719	978·777	978·773	+ 0·004

The values of g in this table are based on the value of gravity at Dehra Dun, 979·063 dynes.

The last column gives the difference ($g''_0 - \gamma_0$) between the theoretical value of gravity at sea level and the observed value reduced to the same surface of reference. The reduction of the observed value to sea level is dependent partly on our estimate of the density of the underlying strata. For our present purposes this density has been assumed to be 2.8. The quantities in the last column show by how much the actual force of gravity differs from what it would be were the density of the underlying matter normal, that is 2.8, and we thus have some indication of the variations of actual densities from normal.

The first seven stations lie in approximately Long. 76° , the remainder in Long. 78° .

At the first three stations, Ujjain, Mhow and Mukhtiar, situated in the Vindhya, gravity is found to be nearly uniformly in defect by about 0.033 dynes. At Mortakka the intensity of the force had increased till it is only slightly in defect. Further still to the south at Khandwa and Asirgarh in the Satpura tracts and at Jalgaon south of the Satpuras, the force of gravity has been found to be in excess, the maximum, so far as the stations visited are concerned, occurring at Khandwa, where the excess is 0.038 dynes.

Generally, then, at stations visited in the Vindhya gravity is found to be in defect while at those in the Satpuras it is in excess. Before we can, however, apply this generalization to these ranges as a whole, further investigation is required. The coincidence here of the line of demarcation between the areas of excessive and defective gravity with the natural boundary between the Satpuras and the Vindhya may be only accidental. Of the five stations on the 78° meridian, at Amraoti and Ellichpur in the Berar plains south of the Satpuras, gravity is in excess by about the same amount as at Jalgaon at the same Latitude 2° further west. As we move northwards across the Satpuras to Hoshangabad on the Nerbudda, the force of gravity decreases somewhat. Shahpur exhibits a noticeable anomaly. Here we find gravity slightly in defect, whereas the results obtained at Badnur and Hoshangabad would point to a small excess. When we compare these results with those collected in previous years, we find that up till now excesses of gravity had been found only at low-lying places under 750 feet above sea level. This last season's work has shown stations at altitudes of from 760 feet to 2,100 feet, where gravity is in excess.

The quantities ($g''_0 - \gamma_0$) are, as has been said, to some extent dependent on the assumed value of normal density. If, however, we

correct the observed value of gravity for height above sea level only and compare this with the theoretical value, we get a series of differences representing the actual effects of the masses standing above sea level without any assumption as to the density.

The comparison is made below :—

Station.	Observed value of gravity corrected for height only = g_o .	Theoretical value at sea level = γ_o .	EFFECT OF MASSES ABOVE SEA LEVEL.	
			Actual ($g_o - \gamma_o$).	Calculated with density 2.8.
Ujjain	978.327	978.802	+ 0.025	+ 0.056
Mhow	978.797	978.763	+ 0.034	+ 0.067
Mukhtiara	978.750	978.753	— 0.003	+ 0.032
Mortakka	978.757	978.743	+ 0.014	+ 0.020
Khandwa	978.787	978.714	+ 0.073	+ 0.035
Asirgarh	978.778	978.694	+ 0.084	+ 0.067
Jalgaon	978.704	978.665	+ 0.039	+ 0.027
Amraoti	978.714	978.665	+ 0.049	+ 0.039
Ellichpur	978.740	978.685	+ 0.055	+ 0.046
Badnur	978.803	978.724	+ 0.079	+ 0.073
Shahpur	978.783	978.743	+ 0.040	+ 0.045
Hoshangabad	978.812	978.773	+ 0.039	+ 0.035

Now by complete compensation is meant that the total amount of matter underlying the station is normal; that the visible mass above sea level is exactly compensated by underlying deficiencies. The combined effect of such visible masses and deficiencies on a pendulum at the station would be *nil*. For such a place ($g_o - \gamma_o$) would be *nil*. This condition is very nearly attained at Mukhtiara, where the actual effect is only 0.003 dynes. The negative sign indicates that slight overcompensation exists. At Ujjain and Mhow the actual effects are about 50 per cent. of those the visible masses would produce were the density 2.8. Here about half the visible masses may be considered compensated.

Mortakka also shows a somewhat similar degree of compensation. At the remaining stations there appears to be no approach to compensation. At the last few on the list the actual effects are almost the same as those calculated on the assumption of a 2·8 density, showing that the visible masses may be supposed "extra" to the normal amount of matter in the crust. At Khandwa we have the discordance between the actual and calculated effects still more pronounced.

We can represent the differences ($g''_o - \gamma_o$) of Table I, as the effects of a disc of matter of a certain thickness and of such density as we may choose to adopt. If we assume that the average crustal density is 2·8 we find that 0·001 dynes would be the effect of a disc of thickness 28·6 feet on a station at its centre.

In the following table the differences ($g''_o - \gamma_o$) are converted into thicknesses of the corresponding disc of density 2·8.

Station.	Height above sea level.	($g''_o - \gamma_o$).	Thickness of corresponding disc.	Hypothetical height.
	Feet.	Dynes.	Feet.	Feet.
Ujjain	1,612	—0·031	887	725
Mhow	1,903	—0·033	944	959
Mukhtiara	926	—0·035	1,001	—75
Mortakka	576	—0·006	172	404
Khandwa	1,014	+0·038	1,087	2,101
Asirgarh	2,077	+0·017	486	2,563
Jalgaon	760	+0·012	343	1,103
Amraoti	1,123	+0·010	286	1,409
Ellichpur	1,314	+0·009	257	1,571
Badnur	2,103	+0·006	172	2,275
Shahpur	1,284	—0·005	143	1,141
Hoshangabad	1,002	+0·004	114	1,116

The quantities given as thicknesses of a corresponding disc may be looked at in another way. Take the case of a station where gravity is,

let us say, in excess, Jalgaon for example. Here gravity, being in excess, points to the matter in the crust underlying this place being of more than normal density. If we were to expand this matter, its total amount remaining the same but the volume increasing until the density became normal, we would find that the imaginary surface of the crust, thus derived, was 343 feet above the present level of the station; that the height of Jalgaon, on this hypothesis, was 1,103 instead of 760 feet. In the case of Shahpur, similarly, where gravity is in defect, showing that the density of the underlying matter is less than normal, it would be necessary to compress the existing mass to make its density 2.8. The amount of compression required would correspond to a lowering of the surface at Shahpur by 143 feet, making the hypothetical height of this station 1,141 feet. The last column of the table above gives these hypothetical heights; the height each place would have supposing the underlying matter expanded or compressed until its density became normal.

We see that along the meridian of 76° between Jalgaon and Ujjain the stations to the south of Mortakka on the Nerbudda bank would all be raised by approximately 600 feet on the average, while those to the north of the same place would be lowered by about 750 feet. The height of the Satpuras would be increased while that of the Vindhya would be decreased. This may, perhaps, indicate a greater thickness of the basalt beds in the Satpuras than in the hills north of the Nerbudda; that a greater amount of matter is present south of this river than to the north. The actual configuration does not reveal this fact. The summits of the Vindhya to the north are just as high as those of the Satpuras to the south. Indeed, the visible masses to the north and south of the river would rather lead one to suppose there was a preponderance of mass to the north. Latitude observations made at Thikri in the Nerbudda valley showed that this supposition was incorrect and this has now been corroborated by the pendulum operations. The latitude observations, however, only pointed to an excess of matter to the south without giving its definite situation. The pendulum has now located the position of this excess of mass.

BOTANICAL SURVEY.

BY

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Eastern India.—Although botanically the Royal Botanic Garden, Calcutta, is not so much part of India as a microcosm of the tropical and subtropical vegetation of both Hemispheres, its inclusion in a review of botanical survey work in India scarcely requires justification. The main scientific work concerned directly with the garden during the year has been the commencement of a census of the shrubs and trees growing therein. Apart from the convenience to the officers both present and future responsible for the garden a census of its plants ought to be helpful to students of Indian Botany in more ways than one. The making of an accurate census however has involved a considerable amount of preliminary labour. In the first place the garden had to be re-surveyed—in the ordinary sense—as the changes in the *facies* of the garden within the last decade had rendered the existing maps no longer accurate and they were in any case on an inconveniently small scale. Accordingly during 1907 an accurate survey of the garden was begun on the scale of 50 feet to the inch and a large map was prepared and finished in 1908.

The garden was then divided—on the map—into squares of a hundred feet side, the lines of squares running due north and south, and east and west. The squares were co-ordinated by letters and figures and here and there throughout the garden the intersections of the lines forming the imaginary squares were fixed on the ground by permanent marks so arranged as to make it quite a simple matter if required to line out by tape any given square or squares. The next procedure was to number and ticket the trees and shrubs—for the census is restricted to such—and allot them to their proper squares. This was done during the cold season of 1908-09 in the following way:—

A line of squares was selected and Bamboo stakes temporarily driven into the ground at the angles of the squares. Coolies then run coarse tape of proper length from stake to stake so that each square in turn was temporarily lined out on the ground. Then every tree and shrub within the square was provided with a zinc label on which its number was stamped, the numbers going on consecutively and irrespective of

the squares. Simultaneously a provisional list giving the numbers of the trees and shrubs and the provisional identification of each, square by square, was drawn up. In this way the whole garden was gone over thoroughly until a complete rough list comprising over 13,000 trees and shrubs, every one of which can now be referred with ease to its place in the garden, was completed. There now remains the checking of the provisional identifications and the preparation and publication of a numerical list and of a systematic list. This work is now in hand and is being carried out as rapidly as other and necessary official work will permit. The first fascicle of the numerical list comprising about 3,000 numbers is ready for the Press and it is hoped the coming cold weather will see another considerable instalment of the numerical list ready for publication.

Outside the Royal Botanic Garden but within or on the frontiers of Bengal attention has been devoted chiefly to the vegetation of the Himalaya with the view of obtaining enough material with exact enough geographical records to justify the commencement of a systematic account of the Flora of Sikkim and the surrounding districts. For this purpose Mr. W. W. Smith, M.A., Curator of the Calcutta Herbarium and Mr. G. H. Cave, Curator of the Lloyd Botanic Garden, Darjeeling, have been deputed to spend two months in the north-west corner of Sikkim studying the vegetation in the field and making as complete collections as possible, to be worked up forthwith.

At the time of writing Messrs. Smith and Cave are still in the field, so that at present one can say only that their explorations have ranged up the Lachen Valley as far as the Kangra Lama Pass in the extreme north of Sikkim and over practically the whole of the Lhonakh district that fills up the north-west corner of Sikkim lying west of the Lachen Valley and north of the Zemu Valley and the big Kinchinjunga glacier. The collections promise to be of a distinctly interesting character, and an account of the expedition and its results will be published in the Records of the Botanical Survey of India.

Towards the end of 1907, Mr. I. H. Burkill, M.A., F.L.S., Reporter on Economic Products to the Government of India visited Nepal, and while there made botanical observations and as full collections as possible. As botanical material from Nepal is by no means abundant the results of Mr. Burkill's trip are awaited with interest. Mr. Burkill has written an account of his trip and of its botanical results which will also be published in the Records of the Botanical Survey.

In the lower and outer hills of the Darjeeling District itself Mr. W. W. Smith, the Curator of the Calcutta Herbarium, collected largely, while his collections were supplemented by those made under the supervision of the officers of the Bengal Cinchona Department.

Although concerned with a region beyond the Frontiers of Bengal, an account in the Journal of the Linnean Society of the *Caryophyllaceæ* of Tibet by Mr. F. N. Williams, F.L.S., calls for mention here, as most of the material on which the account is based was gathered by collectors of the Calcutta Botanic Garden or by officers attached to the Mission to Lhasa in 1903-04. The result of Mr. Williams' elaboration of the material is to increase the number of species of Tibetan *Caryophyllaceæ* from 11—all previously known—to 43, there being 16 species described for the first time.

During the rainy season of 1908, Mr. W. G. Craib, M.A., Officiating Curator of the Herbarium, was deputed to collect on the hills of the District of North Cachar in Assam, so as to supplement the collections made by the writer in the plains of South Cachar District in the same season several years ago. Mr. Craib brought back quite a good collection that was worked up in the Calcutta Herbarium and will form, it is hoped, a basis for a paper on the Flora of Cachar as a whole.

Later on in the same year Mr. Alfred Meebold collected extensively further to the east and mostly in the State of Manipur. Directly the Botanical Survey is under obligation to Mr. Meebold for the gift of a set of his collections and though indirectly not less so to Colonel J. Shakespear, I.A., C.I.E., D.S.O., Superintendent of the Manipur State, for the generous facilities he afforded to Mr. Meebold. The latter's original intention was to cross from Manipur into Burma, but unforeseen circumstances prevented his complete programme so far as this province was concerned from being accomplished. His collections from Burma are therefore not so complete as those from Assam. The staff of the Botanical Survey is quite inadequate to the task of exploring even one province thoroughly and it is quite impossible when there is nominally even but one officer available for him to explore personally in three different provinces in one year. Consequently in Burma local agency was made use of and under the circumstances it was thought better instead of attempting a general collection to restrict collecting work to bringing together a living collection of the orchids of that province.

The Survey has benefited however by the interest taken by officers of other Departments in the flora of the province. Mr. G. E. S. Cubitt,

Deputy Conservator of Forests, Bhamo Division, has studied the vegetation of the surrounding District and has sent his collections for checking and identification to the Calcutta Herbarium. Mr. Cubitt's lists are accompanied with notes on their habitats and uses. From the Southern Shan States Captain R. W. MacGregor, I.M.S., and from the Ruby mines Mr. A. Rodger, Deputy Conservator of Forests, have contributed many interesting species and their lists should prove very useful when the flora of Burma comes to be worked up.

Western India.—The most important botanical event of the year concerned with this side of India is the completion of the Flora of the Presidency of Bombay by Dr. Theodore Cooke, C.I.E. The first part of this work appeared in July 1901 and the concluding part in December 1908. The Flora covers Sind and Baroda in addition to the Presidency of Bombay proper, and is in two volumes, comprising 1,728 pages of description. The completion of the work affords an opportunity of roughly analysing the constituents of the flora of the area covered by it. The species indexed number 2,653 but 151 of these occur only in cultivation or planted, so that the total of the indigenous and naturalised flowering species is 2,502. The number of natural orders—excluding *Cactaceæ*, *Casuarinaceæ*, *Coniferæ*, *Cycadaceæ* and *Bromeliaceæ* that are merely mentioned—actually described is 142. These orders comprise 999 genera and 2,502 species. The ten most important orders as far as the number of genera represented is concerned are :—

ORDER.	GENERA.	SPECIES.
Leguminosæ	81	274
Graminæ	72	223
Compositæ	52	103
Euphorbiacæ	37	101
Acanthaceæ	36	109
Rubiaceæ	34	80
Orchidaceæ	31	74
Scrophularinæ	26	51
Asclepiadæ	25	51
Labiataæ	21	57

If the orders however be ranked according to the number of species irrespective of genera the last three orders of the list above disappear

and are replaced, though not in the same sequence, by *Malvaceæ*, *Convolvulaceæ* and *Cyperaceæ*, thus :—

ORDER.	SPECIES.
Leguminosæ	274
Gramineæ	223
Acanthaceæ	109
Compositæ	103
Cyperaceæ	102 with 14 genera.
Euphorbiaceæ	101
Rubiaceæ	80
Orchidaceæ	74
Malvaceæ	67 with 16 genera.
Convolvulaceæ	64 „ 18 „

This last list is in substantial agreement with the results of Father Blatter who has given an excellent analytical account of the flora of the Bombay Presidency in the Journal of the Bombay Natural History Society before the completion of Dr. Cooke's Flora. Few of the orders show more than four times as many species as genera, but *Malvaceæ*, *Tiliaceæ*, *Vitaceæ*, *Myrtaceæ*, *Ebenaceæ*, *Lentibulariæ*, *Commelinaceæ* and *Cyperaceæ* exceed this proportion. Twenty-three of the orders are represented each by a single species while 19 are represented by a single genus with more than one species.

In the paper above referred to, the Rev. Father Blatter institutes a comparison of the specific contents of the Bombay flora with those of other natural floristic regions of the Indo-Malayan area. Although the Presidency falls within three different botanical regions, the Indus plain, the Malabar and the Deccan regions respectively, its flora is comparatively poor, being not much more than half as rich as the Eastern and Western Himalayan regions and probably less than half as rich as the Burmese and Malayan regions. Father Blatter computes that there are only 127 species truly endemic to the Presidency. The flora shows a preponderance of perennial plants constituting about three quarters of the whole. The Presidency is poor in aquatics and epiphytics, but has a good representation of climbing plants, nearly one-seventh of the total flora belonging to this last type.

Father Blatter has also made a more detailed study of the Flora of the Province of Cutch. Prefacing his paper with an account of the topography and meteorological conditions of the province, he proceeds to give a detailed list of its plants with their times of flowering and their distribution in and out of India. The indigenous species number 345

belonging to 74 natural orders. The dominant orders are roughly those of Sir Joseph Hooker's Indus Plain Province. No endemic species have been found. In addition to the systematic list Father Blatter gives notes on the ordinary cultivated plants of the province and biological notes on certain of the species that show noteworthy adaptations to their environment. He also devotes some consideration to the explanation of the different aspect of the Pacham Island Flora from that of any other part of Cutch and attributes the difference to the special climatic and edaphic conditions prevailing on the Island. He is unable to find any clue from the flora as to the origin of the Rann of Cutch.

Turning now from the general to the particular, Mr. G. A. Gammie, F.L.S., has continued in the Journal already mentioned his account of the Orchids of the Bombay Presidency. He began his account in August 1905 and since then 8 parts have appeared giving description of and notes regarding 19 genera and 40 species. Coloured figures are given of *Dendrobium chlorops* Lindl., *D. barbatulum* Lindl., *Phajus albus* Lindl., *Eulophia pratensis* Lindl., *Cymbidium bicolor* Lindl., *Cottonia macrostachya* Wight, *Rhynchostylis retusa* Bl., and *Ærides crispum* Lindl.

Work on the higher cryptogams is well represented by Father Blatter's list of the Ferns of the Bombay Presidency, in which he enumerates with their geographical distribution 110 species belonging to 49 genera. His conclusions are that the ferns are very poorly represented in the Bombay Presidency, forming only 4 per cent. of the vascular vegetation. Three-fourths of the species known in the Presidency occur in North Kanara, and no endemic species appears to exist.

During the last two years Messrs. L. J. Sedgwick and R. M. Maxwell have made collections of mosses on the Western Ghats, in Konkan and in Kanara. Those collections have been worked up by Mr. H. N. Dixon, F.L.S., who enumerates 22 species, two of them—*Pterobryopsis Maxwellii* and *P. kanarensis*—being described for the first time.

Official systematic work has necessarily been very restricted as the duties of the Economic Botanist lie in other directions. Different members of the staff of the Economic Botanist collected in the course of their tours through Poona, Thana, Belgaum, Kanara and Sind and over 3,000 sheets were added to the Kirkee Herbarium.

Southern India.—Mr. T. F. Bourdillon, F.L.S., Conservator of Forests, Travancore, has during the year made available to botanists his unique knowledge of the Flora of that State by publishing a systematic account of the Forest trees and more important climbers that occur in

Travancore. The book although intended primarily for Forest officers, is indispensable to all who are interested in the Flora of Southern India, and prominence is for that reason given to it in this section of the Board's Report. Mr. Bourdillon describes 582 species of trees and climbers but estimates that an exhaustive study of the flora would probably bring the trees alone to much over 600 species. A synopsis of the natural orders is given at the beginning of the work and keys to the genera and species are furnished in addition to succinct descriptions. Mr. Bourdillon points out that the Travancore Flora combines that of Malabar and that of Ceylon, while it includes many species of wide distribution and not a few endemic species. There are many species that greatly resemble while yet different from species of the Malayan Peninsula, which has a similar varied climate, and Mr. Bourdillon is of opinion that probably at one time a continuous stretch of forest connected those two now distant regions and that the parents of those similar species flourished somewhere in the area between them.

The excellent collections made by Mr. C. E. C. Fischer, I.F.S., in the Coimbatore District have been elaborated by the Rev. Father Blatter. As in his account of the Cutch Flora so here he prefaces his Coimbatore list with a description of the topographical and climatic conditions of the district. It is not claimed that the list is complete, but its value none the less is indisputable. The area covered by the list is roughly the north-eastern half of the District. As far as genera are concerned the ten dominant orders are the same as those in the Bombay Presidency as a whole, although they do not occur quite in the same sequence. As far as species are concerned the ten dominant orders are also the same as for the Bombay Presidency except that in Coimbatore *Labiata* and *Asclepiadaceæ* displace *Cyperaceæ* and *Orchidaceæ*. Altogether the Coimbatore list numbers 1,209 flowering species distributed amongst 119 orders. The flowering times and the elevation of habitat of each species is given.

The district covered is comparable as regards area with Cutch, but there is a marked contrast between the two floras both in regard to actual richness of vegetation and to the dominant orders. In the ten dominant orders in Cutch *Capparidaceæ*, *Cucurbitaceæ*, *Solanaceæ*, *Amarantaceæ*, and *Cyperaceæ* replace *Acanthaceæ*, *Euphorbiaceæ*, *Labiata*, *Rubiaceæ* and *Asclepiadaceæ* in the Coimbatore Flora, though not of course in this precise order as far as specific richness is concerned. As far as generic richness is concerned *Rubiaceæ*, *Euphor-*

biaceæ, *Scrophularinææ*, *Labiataæ* and *Orchidaceæ* that appear amongst the ten dominant orders in Coimbatore, yield place in Cutch to *Cucurbitaceæ*, *Malvaceæ*, *Convolvulaceæ*, *Amarantaceæ*, and *Solanaceæ*. In addition to the flowering species 50 species of vascular Cryptogams, mostly ferns, are enumerated.

During the year material for similar work in other districts of Southern India has been collected but still remains to be worked up. In the Anamalais to the South of Coimbatore collections were made by the acting Government Botanist and his assistant. Mr. Meebold—the same gentleman who collected in Assam—also during his journeys last year in Southern India collected largely in Mysore and a set of his collections from this Province has been kindly presented by him to the Calcutta Herbarium.

North-West India.—The Flora of the Upper Gangetic Plain, at present under preparation by Mr. J. F. Duthie, F.L.S., formerly Director of the Botanical Survey of Northern India, covers the United Provinces of Agra and Oudh with their Sub-Himalayan tract, the south-east corner of the Punjab, the south-eastern third of Rajputana, the greater part of Central India and the central projecting fragment of the Central Provinces north of the line of the Nerbudda and Sone rivers. So far only one volume has been published, giving descriptions of the species up to the end of *Campanulaceæ*. During the year the author—whose work has been greatly hampered by long continued illness—has forwarded enough manuscript to enable descriptions of the intervening orders up to *Scrophularinææ* to be put into type, and more is promised within a short time.

The preparation of the Flora of the Punjab Plain, Rajputana and the North-West Frontier Province is understood to be still in the hands of Mr. J. R. Drummond, I.C.S. (retired), but no information is available as to what progress has been made.

Meanwhile Lieut.-Colonel C. J. Bamber, I.M.S., has commenced the publication in the Journal of the Bombay Natural History Society of a descriptive Key to the Flora of the Punjab, North-West Frontier Province and Kashmir. Although the Key being “intended chiefly for the use of inquirers who have very little knowledge of Botany” is primarily a means of identification irrespective of purely scientific considerations and makes no pretence of being a serious floristic work, none the less it fully merits mention here.

Mr. I. H. Burkill, F.L.S., in his working list of the flowering plants of Baluchistan, gives an account of the botanical works of previous investi-

gators in this Province and furnishes notes on the economic and other uses of the many plants in his list. Altogether Mr. Burkill enumerates 1,191 species distributed over 546 genera and 100 orders. The ten most important orders are—

ORDER.	GENERA.	SPECIES.
Leguminosæ	42	133
Compositæ	52	128
Gramineæ	54	125
Cruciferæ	36	62
Labiatae	23	54
Boraginaceæ	19	52
Chenopodiaceæ	14	36
Umbelliferæ	20	32
Caryophyllaceæ	12	32
Liliaceæ	12	31

Compared with the Bombay Presidency list arranged on the same basis, the same three orders head the list, only in the reverse sequence. Of the remaining seven orders of the Bombay list only *Labiatae* appear in the Baluchistan list. The latter list agrees with Sir Joseph Hooker's list of dominant orders for British Baluchistan given in the *Gazetteer of India* with the exception that *Rosaceæ* given in his list is replaced by *Umbelliferæ* in Mr. Burkill's list. *Rosaceæ*, however, would be the next order to be included in the latter.

Mr. Burkill points out that the flora of Baluchistan is Persian in character and very much less northern than that of Afghanistan: but it is northern enough to contain a violet, a primula, the English hawthorn, an anemone, a gentian, a juniper and plants of many genera familiar in North-Western Europe.

In the North-West Himalaya collections have latterly been made in the Kumaon District under the supervision of Mr. N. Gill, F.L.S., Superintendent of the Government Gardens at Naini Tal. The most important contribution during the year to our knowledge of the North-West Himalaya Flora has been made by Mr. Meebold who has so actively botanised in many parts of India. In 1905 Mr. Meebold travelled in Kashmir, traversing the country from Murree to Ladakh. He collected altogether 1,139 species, and has given an account of the botanical results of his journey and a description of the general botanical features of the region traversed in an article entitled "Eine botanische Reise durch Kaschmir" published this year in the *Botanische Jahrbucher*.

Mr. James Marten, to whom the Botanical Department has been indebted on many occasions in the past, has contributed to our knowledge of the higher Cryptogamic vegetation of the North-West Himalaya in publishing a list of ferns found at and around Mussoorie. In his list 58 species are enumerated, belonging to 29 genera.

General.—Although the Malayan Peninsula is not politically part of India, its inclusion in the Flora of British India and its proximity to Burma justify consideration of its flora here. The publication of materials for a Flora of the Peninsula was commenced by the late Sir George King in 1889, and since then the work has made steady progress. An account of the Monocotyledonous orders was completed by Mr. H. N. Ridley, F.R.S., in 1907. The Polypetalæ and Gamopetalæ orders have also now been finished. The last part pertaining to those orders appeared during the present year and contained descriptions of the natural orders *Gesneraceæ* and *Verbenaceæ*, Mr. H. N. Ridley being responsible for the former, Mr. J. S. Gamble, F.R.S., C.I.E., for the latter. In the *Gesneraceæ* 131 species belonging to 20 genera are described, one genus and two species being hitherto undescribed. The *Verbenaceæ* comprise 72 species belonging to 15 genera, 16 of the species being new to science.

Turning to the consideration of particular families and genera of plants, the most important work of the year is Signor Beccari's Monograph of the Climbing Palms of the genus *Calamus*, forming volume XI of the Annals of the Calcutta Botanic Garden. This is one of the finest botanical works that have ever been published and is unique of its kind. The Palms of this genus are confined mainly to the damp forests of tropical and sub-tropical Asia and the Asiatic Archipelagoes, a few only being found in Africa and Australia. Owing to their ferocious spines and their climbing habit they are very difficult both to collect and to study. Signor Beccari's Monograph consists of over 500 pages of descriptive matter, comprising in addition to a learned introductory essay on the morphology and distribution of the genus, detailed descriptions of over 200 species, of which more than twenty are described for the first time. The monograph is illustrated with 230 magnificent double plates, the plates being all from negatives made by Signor Beccari himself. The plates in their clearness and relief admirably illustrate the possibilities of photography in the service of Botany. Another monograph by the same author and on the same lines treating of the allied genus of palms called *Dæmonorops* is now in the Press.

In addition to those especially important contributions to the study

of particular groups of plants, various botanists in Europe have added to our knowledge in different directions, although here scarcely more than an indication of the various contributions can be given. Sir J. D. Hooker, G.C.S.I., O.M., has described a large number of new species of *Impatiens* or Balsams from the Malayan Peninsula and the Indo-China region. Colonel Prain—in conjunction with Mr. I. H. Burkill in India—has described 17 new species of *Dioscorea*,—the Yam genus—occurring in China, Burma and India. Mr. T. S. Sprague has described the prickly-fruited species of *Euonymus*. Mr. J. Hutchinson has re-examined the Indian species of *Sambucus* and given additional diagnoses of them. Colonel Prain, Mr. J. S. Gamble, Dr. O. Stapf, Mr. J. R. Drummond, Mr. J. Hutchinson, and Mr. N. E. Brown have published in the Kew Bulletin diagnoses of a considerable number of new species from India and the Malayan Peninsula.

During the year, as usual, materials were lent to various Botanical Institutions and botanists in Asia and Europe to facilitate special investigations. The material of the genus *Grewia* was sent to Mr. R. S. Hole, Forest Botanist at Dehra Dun; a general collection from Tibet made by Captain F. H. Stewart, I.M.S., to the Royal Botanic Garden, Kew; *Menispermaceæ* to Professor Diels of Warburg; material of the genus *Sparganium* and of several genera of *Acanthaceæ* and *Rubiaceæ* to the Buitenzorg Botanic Garden; material of several genera of *Euphorbiaceæ* to the Imperial Botanic Garden, Berlin; *Crassulaceæ* to M. Raymond Hamet of the Museum D'Histoire Naturelle, Paris; *Primulaceæ* to M. Petitmengin of the University of Nancy, France, etc.

Physiological.—Dr. C. A. Barber, Sc.D., F.L.S., Madras Government Botanist, continues his studies in root parasitism and during the year published an illustrated account of the haustorium of *Cansjera Rheedii* Gmelin. This species is a climbing shrub of the natural order *Olacineæ*, with a distribution extending from the Upper Gangetic Plain to North Australia. Dr. Barber's anatomical researches appear to support the opinion that the genus *Cansjera* should be transferred to the natural order *Santalaceæ* in which its original founder placed it. *Cansjera* appears to be very catholic as regards the plants with which it chooses to become organically connected, for Dr. Barber enumerates at least 42 different species including *Cansjera* itself as being attacked by the parasite. A detailed account is given of the microscopic appearance of the tissues of the parasite and of its effect on the tissues of the host plants, and a comparison between the haustoria of *Cansjera* and of *Olax* and

Santalum is also made. The paper is illustrated with 11 beautifully finished plates drawn by Dr. Barber himself.

Mr. I. H. Burkill has also continued his investigation on the pollination of flowers in India. His last contribution to this branch of study is an account in the *Journal of the Asiatic Society of Bengal* of observations made in the Autumns of 1904-1906 along the high mountain ridge that separates Nepal from Sikkim in the Eastern Himalaya, and another account of similar observations made in the Spring of 1906 in the North-West Himalaya near Simla. Mr. Burkill describes the floral adaptations in a large number of species for the various modes of pollination by insects or wind or otherwise, and gives analyses of the flora in each case and a list of the insect visitors in the case of insect-pollinated species. Out of 149 species noted in flower in Sikkim, 141 are insect-pollinated. An unusually large percentage (22 per cent.) of the flowers possess pendulous corollas. In the Simla Hills 329 species were noted in flower of which 90·80 per cent. are insect-pollinated. The proportion of flowers with pendulous corollas—8 per cent.—is much smaller than in the Eastern Himalaya, which is probably due to the fact that the flowers in the Eastern Himalaya have to adapt themselves to a much heavier rainfall than in the western part of the range.

A considerable number of papers on the anatomy of plants found in India and adjacent countries have appeared during the year but as their interest is more general than particular to India detailed reference here does not appear to be called for. The more important amongst them are mentioned in the list of publications attached to this report.

Publications.—The results of botanical investigations that have been described in the more important publications of the year have been referred to above, and the subjoined list does not claim to be more than a selection from the total mass of literature with more or less reference to India, issued during the year.

A list of papers on the Botany of India published during 1908-09.

- BAMBER, C. J. . . . Plants of the Punjab. (*Journ. Bom. Nat. His. Soc.* xviii, 4, 835—861, 1908 and xix, i, 59—86, 1909.)
- BARBER, C. A. . . . Studies in root-parasitism. The haustorium of *Cansjera Rheedii*. (*Mem. Dept. Agri. Ind. Bot. Ser.* ii, 5, 37, with 11 plates, 1908.)

- BECCARI, O. . . Asiatic Palms. Lepidocaryæ. Part I. The Species of Calamus. (*Annals Roy. Bot. Gard. Calc. xi, pp. iii, 518 with 288 plates, Calcutta, 1908.*)
- BECKER, W. . . Ein Beitrage zur Veilchenflora Asiens. (*Beih. Bot. Cbl. xx, Abt. 2, 125—127, 1906.*)
- BERNARD, CH. . . Sur une anomalie des fruits de Carica Papaya. (*Ann. du Jard. Bot. Buiten. Ser. 2, vii, 56—68, with plates, 1908.*)
- BLATTER, E. . . Ferns of the Bombay Presidency. (*Fourn. Bom. Nat. His. Soc. xviii, 3, 599—612, 1908.*)
- BLATTER, E. . . The Flora of the Bombay Presidency. (Statistico-Biological Notes.) (*Fourn. Bom. Nat. His. Soc. xviii, 3, 562—571, 1908.*)
- BLATTER, E. . . On the Flora of Cutch. (*Fourn. Bom. Nat. His. Soc. xviii, 4, pp. 756—777, 1908, and xix, i, 157—176, 1909.*)
- BONATI, G. . . Scrofularinées nouvelles de l'Indo-Chine. (*Bull. Soc. Bot. France lv, 509 et 537, 1908.*)
- BOURDILLON, T. F. . The Forest Trees of Travancore. (*pp. 456, Trivandrum, 1908.*)
- BURKILL, I. H., & FINLOW. . The races of Jute. (*Agric. Ledger, 1907-08, 6, 41—137.*)
- BURKILL, I. H. . . A working list of the Flowering Plants of Baluchistan. (*pp. 136, Calcutta, 1909.*)
- BURKILL, I. H. . . Notes on the pollination of Flowers in India. Nos. 5 & 6. (*Fourn. Asiat. Soc. Beng. iv. No. 4, April 1908, pp. 179-231.*)
- COMPTON, R. H. . . The Morphology and Anatomy of Utricularia brachiata Oliver. (*New Phytologist, viii., 4, 117—130.*)
- COOKE, T., & STAPF, O. Andropogon (Dichanthium ?) serrafalcoides. (*Kew. Bull. 10, 1908. 450.*)
- COOKE, T. . . Flora of the Bombay Presidency. ii, pt. 5, Araceæ to Gramineæ with Index. (*pp. 817—1083, London, 1908.*)
- COSTERUS, J. C. . . Pistillody of the stamens in Nicotiana. (*Rec. Trav. Bot. Neerland, iv, 221, with plate.*)

- DANGUY, P. . . Note sur une collection. botanique rapportée du Pamir par le commandant de Lacoste. (*Fourn. Bot. xxi*, 3, 49—53, 1908.)
- DIXON, H. N. . . Mosses from the Western Ghats. (*Fourn. of Bot. xlvii*, 1909, pp. 157—164.)
- DODE, L. A. . . Revue des especes du continent asiatique de la section Tetradium et de la section nouvelle Evodioceras du genre Evodia. (*Bull. Soc. Bot. France. 1908*, lv, 9, 701—707, 1909.)
- DOP, P. . . Contribution a l'étude des Malpighiacées d'Indo-Chine. (*Bull. Soc. Bot. France. lv*, 427—430, 1908.)
- FINET ET GAGNEPAIN . Additions a la flore de l'Asie Orientale. (*Bull. Soc. Bot. France. liv*, 82—90, with plates, 1908.)
- GAGNEPAIN, F. . . Bixacées et Pittosporacées asiatiques (*Bull. Soc. Bot. France, lv*, 544, 1908.)
- GAGNEPAIN, F. . . Contribution à la connaissance des Xanthophyl- lum. (*Fourn. de Bot. xxi*, 10, 241—253, 1908.)
- GAGNEPAIN, F. . . Essai de classification des Scolopia et Flacour- tia asiatiques. (*Fourn. de Bot. xxi*, 7, 164—173, 1908.)
- GAGNEPAIN, F. . . Nouveautés asiatiques de l'herbier du Muséum. (I. Hydrocharitacées, II. Menispermacées, III. Lardizabalées.) (*Bull. Soc. Bot. France. 1908*, lv., 34—41, et 43—48.)
- GAGNEPAIN, F. . . Un arbre oleifere d'Indo-Chine. L'huile de Chaulmoogra et le faux Chaulmoogra. (*Fourn. de Bot. xxi*, 6, 137—144, 1908.)
- GAMBLE, J. S. . . Materials for a Flora of the Malayan Peninsula pt. 21, Verbenaceæ, 1908. (*Fourn. Asiat. Soc. Beng. lxxiv.*, 1909, pp. 729—908.)
- GAMBLE, J. S. . . Acer Osmastoni. *Kew Bull.* 10, 1908, 446.)
- GAMBLE, J. S. . . Boschia Mansoni. (*Kew Bull.* 10, 1908, 445.)
- GAMBLE, J. S. . . Cynometra Bourdilloni. (*Kew Bull.* 10, 1908, 446.)
- GAMBLE, J. S. . . Wrightia sikkimensis. (*Kew Bull.* 10, 1908, 447.)

- GAMMIE, G. A. . . . Indigenous trees and shrubs under observation.
(*Report of Exp. Work, Ganeshkhind Bot. Stat.* 4—15, 1908.)
- GAMMIE, G. A. . . . The Orchids of the Bombay Presidency, pts. VI—VIII (*Fourn. Bom. Nat. Hist. Soc.* xviii, 3, 586—590, 1908, 4, 833—834, 1908; xix, i, 1909, 139—141.)
- GEHRMANN, K. . . . Vorarbeiten zu einer Monographie der Gattung *Bridelia* (*Engler's Bot. Jahrb.* xli, Beibl. 95, 1—42, 1908, with plates.)
- GUEGUEN, F. . . . Enations hypophylles du *Colocasia esculenta* Schott. (*Bull. Soc. Bot. France.* lv., 26—32, with plates, 1908.)
- HERTER, W. . . . *Lycopodium sikkimense*. (*Bot. Jahrbuch.* xliii., 1909, 42.)
- HILLIER, J. M. . . . Lalang grass—*Imperata arundinacea* Cyrill. (*Kew Bull.* 1909, 2, 55—59.)
- HOOKE, J. D. . . . On some species of *Impatiens*. (*Hooker's Icones Plantarum*, ix., 3, 2851—2875, 1908.)
- HOOKE, J. D. . . . On some species of *Impatiens* from Indo-China and the Malayan Peninsula. (*Kew Bull.* i., 1909.)
- HUTCHINSON, J. . . . Notes on the Indian species of *Sambucus*. (*Kew Bull.* 4, 1909, 191—193.)
- KUSANO, S. . . . Further studies on *Æginetia indica*. (*Bull. Coll. Agric. Tokyo* viii, i, 59—78, with plates, 1908.)
- LECOMTE, H. . . . *Sabiacees asiatiques nouvelles* de l'herbier du Muséum. (*Bull. Soc. Bot. France.* 1907, liv, 671—678.)
- MARTEN, J. . . . List of Ferns found at and around Mussoorie, 1908. (*Fourn. Bom. Nat. Hist. Soc.* xix., i, 1909, 179—183.)
- MASTERS, M. T. . . . On the distribution of the species of Conifers in China and on the occurrence of the same species in neighbouring countries. (*Fourn. Linn. Soc., London*, xxxviii., 198—205, 1908.)
- MEEBOLD, A. . . . Eine botanische Reise durch Kaschmir (*Bot. Jahrbuch.* xliii, iii, pp. 63—90, 1909.)

- NESTLER, A. . . . Die hautreizende Wirkung der *Primula mollis* Hook. und *P. Arendsii* Pax. (*Ber. deutsch. Bot. Ges.*, xxvii, 468—475, 1908.)
- PETITMENGIN, M. . . . Revue critique des Primulacées asiatiques. (*Bull. Acad. Intern. Geogr. Bot.*, xvii, Nos. 225—226, 334—338, 1908.)
- PRAIN, D. . . . A new species of *Butea*, with notes on the genus. (*Kew Bull.* 1908, 9, 381—387.)
- PRAIN, D., & BURKILL, I. H. . . . *Dioscorearum novarum descriptiones quædam.* (*Journ. and Proc. Asiat. Soc. Bengal*, iv., 2, 447—457, Sept. 1908.)
- RENNER, O. . . . Beiträge zur Anatomie und Systematik der Artocarpeen und Conocephaleen insbesondere der Gattung *Ficus*. (*Diss. München*, 1906, 129.)
- RIDLEY, H. N. . . . Materials for a Flora of the Malayan Peninsula. Gesneraceæ. (*Journ. Asiat. Soc. Beng.* lxxiv, Pt. 4, pp. 730—793, 1909.)
- SPRAGUE, T. A. . . . The prickly-fruited species of *Euonymus*. (*Kew Bull.* i, 29—36, 1908.)
- STAPF, O. . . . *Arthraxon Meeboldii*. (*Kew Bull.* 10, 1908, 449.)
- STAPF, O. . . . *Mussænda Treulleri*. (*Kew Bull.* 10, 1908, 449.)
- STAPF, O. . . . *Pyrus Pashia* var. *Kumaoni*. (*Bot. Mag.* 53, 1909.)
- WILLIAMS, F. N. . . . The Caryophyllaceæ of Tibet. (*Journ. Linn. Soc.*, xxxviii., 268, 395—407.)
- WRIGHT, C. H. . . . *Alpinia bracteata* Roxb. (*Bot. Mag.* 50, 1909.)

ECONOMIC BOTANY.

BY

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Wheat.—The most important original contributions to the Economic Botany of India published during the year ending June 30th, 1909, relate to the improvement of the wheat crop. The papers actually published during the year under review as well as those still in the press are the result of the discussion on the best means of developing the wheat production of this country which took place at the second meeting of the Board of Agriculture held at Pusa in 1906. Evans has completed a survey of the wheats of the Central Provinces and Berar based on an examination of ripe ears sent in from the various districts. In this paper a good deal of information is given on the cultivation and uses of the varieties, but the author has not yet worked out by means of pure line cultures the agricultural characters and qualities of the various wheats at present in cultivation in this Province.

The writer, in collaboration with G. L. C. Howard, has published a memoir on the varietal characters of Indian wheats. This paper deals with the influence of external conditions on the various characters of wheat in India and with the principles of classification. It was found that wheats cannot be completely classified from ripe ears only as the botanical varieties are themselves complex and contain types differing in field characters. Among the characters most influenced by environment the consistency of the grain takes the first place. The detailed classification and description of the wheats of the Punjab was included in this paper as an example of the system of classification finally adopted. Several cases of natural crossing, discovered at Lyallpur in 1907, are described, and it is proposed to publish a further paper on this subject. A bulletin has also been issued during the year on the milling and baking qualities of Indian wheats. It was found that some of the wheats grown at Pusa and Lyallpur were harder and higher in nitrogen than the soft whites like Mozaffernagar usually exported to England. While these harder wheats gave decidedly better results in the mill and bake-house than Mozaffernagar white, a Pusa selection, No. 6, gave the best results of all. Contrary to what has often been stated, India can produce

much stronger wheats than those usually exported and this aspect of the subject is being followed up.

A monograph on Indian wheat was completed by the writer, in collaboration with G. L. C. Howard, during the year under review, and is now passing through the press.

Cotton.—Considerable attention is being paid to Indian cotton, and several papers have appeared during the year. Fyson has published his results on the hybridising of Indian cotton, the work on which was commenced in Madras in 1904. Leake at Cawnpore, has issued a second paper on the same subject dealing with buds and branching. This work emphasises the great importance of the study of the growing plant both from the point of view of classification and also of breeding early flowering types of suitable habit for North-West India. Dobbs at Lyallpur, has published some interesting observations on the natural crossing of cottons in the field and the results are best given in the author's own words. He states "By separate sowing on the farm of seed from single known parents evidence has been obtained, conclusive to any one familiar with the common reactions caused by hybridisation, that a very large proportion of the cottons on the farm, particularly those that are most vigorous, are crosses between distinct varieties within each of the above main types, e.g., seedlings grown from a supposed "Khaki" American parent having a light brown lint gave "Khaki", light brown and pure white lint in approximately "Mendelian" proportions. Again "Dharwar" cotton consists, on the farm, of innumerable varieties, early and late, productive and unproductive, of which half do not breed true to type; and it may be inferred that this variation has arisen by hybridisation. In this lie great possibilities of improvement by mere systematic selection as well as the explanation of the extraordinary deterioration noted below of Egyptian cotton grown from unselected seed. It is in fact clear that where a valuable variety grows in close proximity to a worthless one of the same main type, great care, in the following year, in the selection of parents for seed production, is necessary, if the valuable strain is to be kept pure. This agreeing with experience in America where (pages 131 and 132 of the *Year Book of the U. S. A. Agricultural Department*, 1903), it is advised that seed fields of valuable cotton should be located 'half a mile or more from any other cotton,' should be taken into account in seed growing in the future." The published evidence on the frequent existence of natural crossing in cotton in India may be regarded as absolutely conclusive and this circumstance will have to be taken

into serious account in the growth and distribution of pure seed to the cultivators and in the introduction of exotics.

Fibres.—Several papers on fibres have appeared during the year. Burkill and Finlow have written a long paper on the races of Jute, the result of investigations on this crop commenced in 1900. The objects of this work have been to throw light on the question of the alleged deterioration of jute and to discover the most suitable races for cultivation in the various districts. The field notes are given in considerable detail and the authors have provisionally distinguished thirty-three races of *Corchorus capsularis*, round podded jute, and five races of *C. olitorius*, long podded jute. Finlow has given a general survey of the work in progress on fibre plants in India in the *Agricultural Journal of India* in which a reference is made to the report on the investigations (carried out by Messrs. Cross and Bevan) to the Secretary of State for India on the "heart damage" of baled jute. The chief characteristic of this deterioration is an entire loss of tensile strength of the fibre and Messrs. Cross and Bevan, while suggesting treatment with formalin as a method of prevention, are of opinion that further co-operative work is desirable.

The report of the sub-committee appointed by the Board of Agriculture in 1903 to consider the question of the extension of cultivation of fibre plants in India has issued its report which is published as an appendix to the *Proceedings of the Board of Agriculture at Nagpur in 1909*. "The Committee believes that it is possible to extend largely and profitably, in the immediate future, the cultivation of jute, Sann-hemp and *Hibiscus cannabinus*, and that later on, it is possible that a portion of the linseed grown over large areas in various parts of India, may be utilized for the production of fibre as well as seed. A considerable increase of Agave cultivation is possible in Assam and in tracts which have similar physical and climatic conditions. Successful Rhea cultivation must apparently be limited to a comparatively narrow zone where both climate and soil are particularly suitable. The Committee affirms that jute is a very paying crop and believes that it can usually be followed by a food crop in the same year.

"The Committee lays great stress on so arranging the rotation of food and fibre crops that the encouragement of the latter shall not be at the expense of the former. From this point of view, those fibre crops, which occupy the ground for one season only, are preferable to those of a perennial nature.

"The Committee believes that the demand for fibres is bound to increase, as they are essential for nearly all branches of trade, also that it is not likely that prices will fall so low as to render fibre cultivation in India unremunerative."

The flax experiments conducted in Behar have been continued during the year and have been placed on a more permanent footing. It is fortunate that the prompt action taken by the Behar Planters' Association to eradicate the spread of flax dodder has apparently been successful.

Some minor papers on fibre plants include a review of existing information on the use of *Urena lobata* as a possible jute substitute by Abbey-Yates and a paper on the fibre plants of Upper Burma published by Aubert in the *Agricultural Journal of India*. Among the fibre plants utilised by the people, *Hibiscus cannabinus* is the most important. The question of the future utilisation of *Sida* as a fibre plant is the subject of a short note by Finlow.

Fruit.—Although continued attention is being paid to fruit growing in India but few papers have appeared during the year. The second report on the Pusa fruit experiments by the writer is in the press while Woodhouse has published an interesting note on the mangoes of Bhagalpur of which thirty-eight kinds, arranged in three groups, are described.

Miscellaneous.—During the year an important work of reference on the Economic Botany of India has been completed by Watt and published by the Secretary of State for India. An abstract of this author's *Dictionary of Economic Products of India* has long been greatly needed and the compression which has been practised in the preparation of the new *Commercial Products of India* has resulted in a much more useful and workable treatise. It is probable that the new book will remain for many years a standard work of reference on the numerous agricultural products of India.

Gammie has issued a long paper on the field, garden and orchard crops of the Bombay Presidency, the result of eight years' observations on the subject. A more extended illustrated edition is promised shortly. The various economic plants are grouped according to their natural orders, and in some cases, especially among the *Gramineæ*, the cultivated varieties have been partly worked out in detail. The author has also added general agricultural notes to some of more important species.

Barber has published another interesting paper on root parasitism in Southern India. He has studied in detail the anatomy of the

haustorium of *Cansjera Rheedii* which was found to be parasitic on more than 40 other plants. A summary of existing information on the use of dyes from flowers in India has been compiled by Burkill, while Evans has published an account of the varieties of potatoes grown in the Central Provinces. An interesting summary of the tea experiments at Heeleaka, conducted on behalf of the Indian Tea Association by Hutchinson has appeared. The feature of this report is the use of curves in expressing graphically the plot results and the care that has been devoted to the presentation of the subject. Rahar (*Cajanus indicus*) gave the best results among the green manure plants. Hutchinson has also issued a report on the causes of taints in packed teas which are considered to be caused by defects in the box boards, often due to the use of unseasoned timber, and not to faulty methods of manufacture. Papers on cassava have been contributed to the *Agricultural Journal of India* by Booth-Tucker and Pillay. An account of the introduction of two rubber-yielding trees, *Manihot dichotoma* Ule and *M. piauhyensis* Ule, is described by Gage in the *Annual Report of the Calcutta Botanic Garden for 1908-09*.

List of papers on Economic Botany in India published during the year ending June 20th, 1909.

- ABBEY-YATES, R. *Urena lobata*. (*Agr. Ledger*, No. 4, 1908-09.)
- AUBERT, L. Some Fibre Plants of Upper Burma. (*Agr. Jour. India*, iii, 1908, p. 333.)
- BARBER, C. A. Studies in root parasitism. IV. The haustorium of *Cansjera Rheedii*. (*Mem. Dep. Agr. India, Bot. Ser.*, ii, No. 5, 1908.)
- BOOTH-TUCKER, F. Cassava as famine food. (*Agr. Jour. India*, iii, 1908, p. 227.)
- BURKILL, I. H. Dyes from Flowers. (*Agr. Ledger*, No. 2, 1908.)
- BURKILL, I. H., &
FINLOW, R. S. The races of Jute. (*Agr. Ledger*, No. 6, 1907.)
- DOBBS, A. C. (*Annual Report of the Lyallpur Agr. Station*, 1907-08.)
- EVANS, G. Varieties of wheat grown in the Central Provinces and Berar. (*Nagpur*, 1908.)
- EVANS, G. Varieties of potatoes grown in the Central Provinces. (*Nagpur*, 1908.)

- FINLOW, R. S. . . . Experimental work on Fibres in India (*Agr. Jour. India, iv, 1909, p. 16.*)
- FINLOW, R. S. . . . Sida Fibres. (*Agr. Jour. India, iv. 1909, p. 200.*)
- FYSON, P. F. . . . Some Experiments in the hybridising of Indian cottons. (*Mem. Dept. Agr. India, Bot. Ser., ii. No. 6, 1908.*)
- GAGE, A. T. . . . Annual Report of the Calcutta Bot. Gardens for 1908-09.
- GAMMIE, G. A. . . . Field Garden and Orchard Crops of the Bombay Presidency. (*Bull. 30, Dept. Agr. Bombay, 1908.*)
- HOWARD, A., &
HOWARD, G. L. C. . . . The varietal characters of Indian wheats. (*Mem. Dept. of Agr. India, Bot. Ser. ii. No. 7, 1909.*)
- HOWARD, A., &
HOWARD, G. L. C. . . . The milling and baking qualities of Indian wheats. (*Bull. 14, Agr. Research Inst., Pusa, 1908.*)
- HOWARD, A. . . . On Flax dodder. (*Bull. 11 Agr. Research Inst. Pusa, 1908.*)
- HUTCHINSON, C. M. . . . Report of the Heeleaka Experiment Station, 1905—1908. (*Calcutta, 1908.*)
- HUTCHINSON, C. M. . . . Report on the causes of taints in packed teas. (*Calcutta, 1908.*)
- LEAKE, H. M. . . . Studies in the Experimental Breeding of Indian Cottons; an introductory note. Part 2. On Buds and Branching. (*Four. Proc. Asiat. Soc. Bengal, v. No. 1, 1909, p. 23.*)
- PILLAY, T. P. . . . The cultivation of Tapioca in Travancore. (*Agr. Jour. India, iii. 1908, p. 366.*)
- WATT, SIR G. . . . The Commercial Products of India. (*London, 1908.*)
- WOODHOUSE, E. J. . . . The Mangoes of Bhagalpur. (*Quarterly Four. Dept. Agr., Bengal, ii, 1909, p. 168.*)
- PROCEEDINGS of the Board of Agriculture in India held at Nagpur, Calcutta, 1909, p. 54.

MYCOLOGY.

BY

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The campaign against the palm disease of the Godavari Delta is still being continued by means of the special staff sanctioned by the Madras Government. There has been no general recrudescence of the disease in the early months of this year such as occurred last year, and during a tour in January a very small number of newly diseased trees were seen.

During a visit to Kashmir an enquiry was made into the diseases of Mulberry and of fruit trees. The result of part of this work has been published while the rest is in progress.

The study of the wilt disease of pigeon-pea has been concluded and the disease has been definitely ascertained to be due to *Fusarium udum* Butl. A memoir on the work is now in the press. The cause of the gram wilt has also been definitely determined. Enquiry into cotton, indigo and pigeon-pea wilts was continued.

Renewed investigation to elucidate the methods of infection of red-rot on sugarcane has been undertaken and work is in progress on the life histories of other sugarcane diseases including a new one from Madras.

A disease of ginger is also under investigation and also linseed rust, citrus diseases, papaya stem-rot, and a new anthracnose on Val (*Dolichos Lablab*). Some species of the rare genus *Choanephora* and the two maize smuts of India have been studied and a successful attempt has been made to work out the life history of the very obscure paddy smut.

Publications.

- BUTLER, E. J. . . . The Mulberry disease caused by *Coryneum Mori* Nomu. in Kashmir with Notes on other Mulberry Diseases. (*Mem. Dep. Agric. India, Bot. Ser., ii, No. 8, April 1909*).
- HOWARD, A., & G. L. C. Note on Immune Wheats: (*Journ. Agric. Science, ii, Part 3, Dec. 1907*).

- PILLAI, N. K. . . . Untersuchungen über den Einfluss der Düngung und anderer Faktoren auf die Tätigkeit der Mikroorganismen des Bodens, February 1908.

FOREST BOTANY.

BY

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(I)—Work done at the Imperial Forest Research Institute.

1. During the rains from July to October the Forest Botanist delivered the usual course of botanical lectures to the first year students of the Imperial Forest College and in addition gave a course of botanical instruction to the third year students. The Botanist was also in charge of the College students on tour during November-December 1908 and again during May-June 1909 while March was as usual occupied with the Forest College Annual Examinations. The Manual of Botany prepared by the Botanist for the use of the Forest College Students was seen through the press and published during the year.

Educational work of Forest Botanist.

2. The Botanist took charge of the valuable Saharanpur Herbarium at Saharanpur on July 25th, 1908. The collections were forthwith removed to Dehra Dun and suitably housed there. When first taken over they were in considerable disorder, many of the sheets, including all those of *Grewia*, were missing and a large quantity of unnamed material was included which required working up.

Facilities for Research work.

(a) Herbarium and Collections.

Mr. N. Hutchinson, the Curator, has, however, worked hard at arranging and putting the collections in order and this work will be completed early next year. The majority of the missing *Grewia* sheets have fortunately been recovered during the year from the Calcutta Herbarium where they had been misplaced and the remainder together with other missing specimens are expected to be returned shortly from Mr. J. R. Drummond to whom they had been loaned.

In order to economize space the amalgamation of the Saharanpur collections with the Herbarium of the Forest College and Research Institute was commenced in April and the work will be completed early next year.

This amalgamated Herbarium will certainly rank as the most important in India next to the historic collections at Calcutta and will form one of the most valuable assets of the Research Institute not only for research work but also for the purpose of identifying specimens for Forest Officers and others, a work which hitherto could only be undertaken on a very small scale.

In addition to the *Grewia* specimens which were received for research purposes and which will not be finally incorporated until the research is complete 760 sheets were added to the Herbarium during the year. The most important contributions were from Mr. J. H. Lace and Mr. D. O. Witt, the latter sending duplicates of his Berar collections. Mr. A. W. Lushington also contributed an interesting set of specimens of root suckers of various species from Madras.

A valuable set of duplicates was received from the Calcutta Herbarium during the year, and in future it is proposed to extend this system of interchanging duplicates with other Indian herbaria.

Specimens were identified during the year for Forest Officers in Madras, Burma, Central Provinces, Andamans, Bengal and Punjab. The principle adopted in dealing with the Botanical Collections at the Research Institute has been to divorce as far as possible the collections required only for educational purposes from those required for research and reference purposes generally. Apart therefore from the main reference herbarium a small separate herbarium is maintained for the use of the College students and towards the close of the year a commencement was made with the formation of an educational collection of glazed show cases designed to illustrate the botanical course of lectures and to exhibit species of forest importance and types of the chief natural orders and groups of plants.

3. When the Botanist took charge of the Saharanpur Herbarium it

(b) **Botanical Library.** was found that the valuable library, which was formerly attached to it, had been removed

to Cawnpore and placed in charge of the Economic Botanist to the Government of the United Provinces. This naturally discounted the value of the Herbarium considerably. On representations made by the Forest Botanist, however, it was finally agreed that some 400 of the volumes of

special value for the Herbarium should be returned to it. These books are expected early next year and will greatly increase the value of the existing Botanical Library.

During the year several valuable volumes were added to the botanical section of the College Library at an expenditure of Rs. 23. At the close of the year a revised scheme of classification of the botanical books was drawn up and the preparation of a new catalogue commenced.

Shortly after the close of the year the entire botanical section of the library was removed to the Herbarium where it is most conveniently situated for reference.

4. Want of sufficient accommodation has very seriously hampered all research work up to date. Until quite

(c) **Accommodation.** recently no laboratory, with facilities for microscopic work, and no suitable experimental garden were available. Towards the close of the year, accommodation for the herbarium, botanical office, library, laboratory and experimental garden was secured in the immediate neighbourhood of the Botanist's bungalow. The botanical branch of the Research Institute may therefore now be said to have been for the first time satisfactorily organised and future progress with research work should be rapid and satisfactory.

5. The following subjects were included in the research programme sanctioned for the year under report:—

Research work of Forest Botanist.

- (a) Study of Teak coppice and reproduction.
- (b) Study of Forest Grasses, with special reference to the effects of fire upon them.
- (c) Study of the various species or forms of *Grewia* of economic importance with special reference to the production of a satisfactory classification and description of the same.

6. As regards the first subject some of the notes and observations collected by the Botanist in the Central Provinces during the previous year were worked up and the results sent to the Press for publication in the form of a Pamphlet. The results obtained indicate that, contrary to a widely spread opinion the coppicing of teak towards the close of the period of vegetative activity in September-October is not injurious.

This probably applies also to the case of many other deciduous species and is a matter of considerable importance, for the prohibiting of all fellings during the rainy season has frequently resulted in a considerable loss of revenue.

Another important point noticed, which, however, requires further investigation, is that felling low in the season of vegetative rest is apparently responsible for the frequent death of stools of important deciduous species and that if coppice fellings must be carried out (as they usually are) during the resting period, cutting high appears to be frequently desirable.

The fertility of the seed produced by coppice shoots is another question of great importance which received attention. At the close of last year Mr. McCrie sent the Botanist a sample of undoubted teak coppice seed which he had collected himself from 9-year old coppice shoots in the Saugor Division of the Central Provinces. The seed was sown at the Research Institute in July 1908 and it germinated towards the close of the year under report and produced healthy seedlings. The fact has therefore been proved that teak coppice shoots of only 9 years growth are capable of producing good fertile seed. The age at which coppice shoots produce seed of course depends to a great extent on the age of the mother tree felled and the nature of the stool.

7. The study of the oecology of Forest Grasses was commenced during the year under report, with special reference to the effect of fire upon their distribution and development and the relations existing between them and our important forest trees. During the year under report it was only possible to make a very small beginning with this work. The Botanist made a short tour in the Siwalik Forest Division during the period November 1908 to January 1909, but as he was also in charge of the College students on tour during November-December 1908 very little time was available for research.

Attention was mainly confined to 9 important local species which are widely distributed in Sál forests and careful notes were collected in the forest in as many localities as possible regarding the conditions under which the various species grow well in nature, the effect of fire upon them, the power of the different species to improve the soil, and other points.

The information collected has, it is believed, satisfactorily established the following facts of interest among others :—

- (a) The damage done by fire depends mainly on the character of the soil, the season at which the fire occurs and the species of grass. Firing by no means necessarily kills out delicate and valuable fodder grasses and favours the growth of coarse growing species. Cases have been seen where fire

has had precisely the opposite effect ; and species which produce delicate annual culms are often very resistant to fire damage.

- (b) Some grasses indicate with great accuracy whether a certain soil is, or is not, suitable for the growth of valuable trees like Sál and their appearance in forest blanks tells us whether we can reasonably hope to successfully stock such areas with a particular species or not.

In order that Forest Officers generally may be able to avail themselves of any useful results which are obtained from time to time, it is essential that they should be able to recognize the grasses concerned. In order to facilitate the identification of the species dealt with therefore it is proposed to publish together with the results obtained full descriptions and illustrations of the different species. These illustrations will include dissections of the flowers and illustrations of the glumes on which the identification of the species largely depends and which have hitherto been inadequately dealt with in the published illustrated works on Indian grasses.

All the species at present under study were planted in the Experimental Garden at Dehra Dun during the year in order that their development might be watched and the differences of growth observed which are exhibited by burnt and unburnt plants respectively. It is also obviously advisable that all conclusions based only on observations made in the forest should so far as possible be checked by experimental cultivation.

No publication was possible during the year partly on account of insufficient time being available for the preparation of the detailed descriptions and drawings of the different species and partly owing to the advisability of observing one complete season's growth before publishing.

This study of forest grasses is greatly facilitated by the fine collection of grasses contained in the College Herbarium which was mainly accumulated by Mr. Duthie and largely through the help of Forest Officers.

8. As regards the subject of *Grewias*, although the results are not yet ready for publication, it seems advisable to give here a brief review of the work which has been undertaken and of the lines on which it is proceeding, seeing that this subject of research has been under study now for 2 years, but in considering the progress made the fact must not be

lost sight of that very little time has been actually available for research work during this period.

The study of this genus, the existing classification of which is very unsatisfactory and the synonymy of which is in great confusion involves three distinct classes of work as follows :—

- (a) The accurate determination of the original types which are the authority for existing names and of the date of their effective publication.
- (b) The careful study of the various forms in the field in order to determine the extent to which the various types keep constant in nature.
- (c) The preparation of descriptions and illustrations of the various specific and varietal groups which study in the field, as checked by the careful examination and dissection of herbarium material, shows to be worthy of separate description and definition. This study at present deals with 12 forms each of which has at one time or another received a separate specific name. The united area of distribution of these forms covers practically the whole of India and Burma. To any one acquainted with the confusion at present characteristic of the classification of this genus the magnitude of the work will be apparent, especially as it involves at least a general acquaintance with all the forty odd Indian species of the genus in addition to the detailed study of the forms under special consideration. The non-success also with which Indian botanists have for several years worked at this problem is a sufficient guarantee of its peculiar difficulty.

PART A.—*Determination of Types.*

Of the work defined above this is the portion which offers the greatest difficulty to workers in India owing to the fact that most of the types are stored in European Herbaria and that the publications containing the original descriptions are frequently not available in Indian libraries. In this part of the work therefore the co-operation of European botanists is essential.

The greatest help was received from the authorities at Kew during the year in the shape of authentic drawings and descriptions of type specimens without which this research could not have been successfully carried on.

The writer has also to acknowledge the receipt of several valuable photographs of types most generously sent to him by Mr. H. H. Haines of the Forest Department while he was on leave in England. Thus, although actual access to the types would of course have been desirable, if it had been possible, it is believed that this portion of the work is being satisfactorily dealt with.

PART B.—*Field-work.*

As regards this division of work it is unfortunate that the College educational duties do not permit of extended tours being undertaken for the purpose of studying the various forms in the forest. The opportunities which have been available however have been utilized as far as possible by confining attention mainly to those areas where various types come into contact.

Thus during the year under report the connection between the forms known in Northern India as *Grewia elastica* Royle, *Grewia vestita* Wall, *Grewia leptopetala* Brandis, *Grewia asiatica* Linn. and *Grewia sapida* Roxb. was carefully studied in the Siwalik and Jaunsar Forest Divisions while during the previous year the connection between *Grewia tiliæfolia* Vahl, *Grewia leptopetala* Brandis and *Grewia elastica* Royle was studied on the Satpuras in the Central Provinces.

This field work, limited though it has been, has proved of the utmost value and by giving a correct idea of the variations of certain forms in different localities it has, it is believed, laid a sound basis for the study by analogy of other forms received from localities which it has not been possible to visit. The fact that tours must occasionally be made at unsuitable seasons of the year when satisfactory specimens of flowers and fruit are not available is a drawback, but selected trees have been numbered and marked in different localities in the Jaunsar and Siwalik Divisions and specimens are collected from these marked trees at different seasons of the year.

PART C.—*Herbarium-work.*

In addition to the great advantage of being able to personally study many of the species in the forest in different localities and at different

seasons the Botanist has been able to assemble, largely owing to the help of other Forest Officers, a practically unique collection of herbarium specimens of the species under study. As an indication of the extent of this collection and of the readiness with which Forest Officers in various parts of India and Burma have helped and are helping this research, it is sufficient to note that, in addition to collections made by the Botanist himself, valuable specimens were received during the year from the following localities :—

United Provinces, Central Provinces, Madras, Bombay, Baluchistan, Bengal, Eastern Bengal and Assam and Burma.

When this work is completed the help given by the various officers will be acknowledged individually and at present the Botanist desires to express his thanks to the Chief Conservators and Conservators of the Provinces enumerated above and the District Officers mentioned and especially to Mr. Lace and other Burma Officers for specimens of forms which are at present very imperfectly known and the connection of which with species described from Java requires to be carefully worked out. The majority of the specimens received are of peculiar value, consisting as they do of extensive series of specimens collected at different seasons from the same tree and accompanied as they are by valuable notes. In most cases also specimens of the wood and bark have also been sent, thus enabling the wood of the various species to be accurately described.

In addition to these collections belonging to the Research Institute the Superintendent, Royal Botanic Garden, Calcutta, most kindly sent the Botanist during the year all the sheets of *Grewia* belonging to the General Herbarium of the Botanic Gardens for examination. The greatest help has also been given during the year by Captain Gage, Superintendent, and Mr. W. W. Smith, Curator of the Herbarium, of the Royal Botanic Garden in the way of supplying authentic copies of drawings and descriptions of types and other information asked for. Mr. I. H. Burkill, Reporter on Economic Products to the Government of India, also very kindly sent the Herbarium Collection of *Grewias* belonging to his office during the year for examination.

The final work of preparing the detailed descriptions and illustrations of the various groups which study up to date shows to require separate description and definition was commenced at the close of the year and the entire results of this research will, it is hoped, be published next year.

9. The Botanist was on tour in the Siwalik Division from November 19th, 1908, to January 25th, 1909, and in the Jaunsar Division from May 10th to June 26th. During February the Botanist attended a Forest Conference at Lahore.

Tours.

10. A quantity of seeds and cuttings of forest species was despatched during the year to the Conservator of Forests, Southern Nigeria, Chief Conservator of Forests, Cape Town, Consul-General for Portugal, Bombay, and the Director of Forests and Gardens, Port Louis, Mauritius. The want of a good reference collection of fruits and seeds of forest species has been felt during the year and a commencement has been made with the formation of such a collection. It is obviously of the first importance to insure that seeds despatched in compliance with the various indents should be correctly identified.

II.—Work done elsewhere.

11. Dr. Barber has continued his study of the anatomy of root parasites. He finds that so far as the structure of the haustorium is concerned *Cansjera Rheedii* agrees rather with *Santalum* than with *Olex* and considers that this evidence supports the proposal previously made on other grounds to transfer *Cansjera* to the *Santalaceæ* in which order it was originally placed.¹ Winifred Smith has studied the anatomy of various Sapotaceous seedlings including those of the species *Bassia latifolia* and *Mimusops Elengi*.²

Anatomy.

12. Professor Beccari's valuable monograph of the species of *Calamus* was issued during the year.³ Dr. T. Cooke's most useful *Flora of the Presidency of Bombay* was completed during the year. Mr. H. H. Haines continued his work on the *Flora of Chota Nagpur*. Mr. D. O. Witt published a descriptive list of important forest species found in the Berar Circle of the Central Provinces, and Mr. A. E. Lowrie continued work on the list referring to the Southern Circle of the Central Provinces which is we believe to contain photographs of the species dealt with.

Monographs, Floras.

¹ *Memoirs of the Department of Agriculture in India, Botanical Series*, Vol. 11, No. 5.

² *Botl. Trans. Linn. Soc. of London*, Vol. VII, p. 189.

³ *Annals Royal Bot. Garden, Calcutta*, Vol. XI,

New species and change of
name.

13. The following important species were published during the year :—¹

Pogostemon hispidus Prain—a plant of Assam and Burma.²

Butea pellita Hook—a plant of local occurrence in the neighbourhood of Naini Tal.³

Boschia Mansoni Gamble—a large tree of Burma.⁴

Acer Osmastoni Gamble—a large tree of the Sikkim Himalaya and Darjeeling.⁵

Cynometra Bourdillonii Gamble—a medium sized tree of Travancore.⁶ R. H. Bunting has examined the type of *Rotula aquatica* Lour and identifies it with *Rhabdia lycioides* Mart, so that the former, which is the older, must now stand as the correct name of this well-known plant.⁷

14. A considerable amount of somewhat haphazard work has been carried out by local officers in the various provinces in the way of cultivating exotics. A considerable degree of success continues to attend the cultivation of various rubber yielding species in the South Thana Division of Bombay.

Introduction of Exotics.

15. Forest officers in all provinces most generously helped the Forest Botanist with specimens required for his research work as noted in paragraph 8 above.

Specimens collected.

A number of botanical specimens were also collected for the Reporter on Economic Products to the Government of India, for the Hyderabad and Nagpur Industrial Exhibitions, for the Gass Forest Museum, Madras, Balaghat Training School, Imperial Mycologist, Pusa, and others.

16. A subject of great interest in India and one which will, it is hoped, be further elaborated has been broached by Professor Paul Brühl in an article dealing with some of the alien plants of Bengal.⁸ The number of such aliens which have successfully established themselves over very extensive areas in India is considerable and the study of their extension and distribution is one of the greatest interest and one which increases our knowledge of the conditions necessary for the existence and successful extension of the indigenous

Plant distribution.

¹ *Kew Bulletin* No. 6 of 1908, p. 254.

² *Bott. Trans. Linn. Soc. of London*, Vol. VII, p. 189.

³ *Kew Bulletin* No. 9 " p. 385.

⁴ " No. 10 " p. 445.

⁵ " " " p. 446.

⁶ " " "

⁷ *Journal of Botany*, XLVII, p. 269.

⁸ *Journal As. Soc. of Bengal*, IV, No. 11, p. 603.

species which are displaced by the foreigners. In Dehra Dun *Asclepias curassavica* has spread rapidly along the canal banks in recent years.

17. The following are among the more important publications of the year concerned with Indian Forest Botany :

- BRÜHL, P. . . . Recent Plant Immigrants. (*Four. Asiat. Soc. Beng., iv, No. 11, p. 603*).
- HOLE, R. S. . . . Manual of Botany for Indian Forest Students.
- IYER, V. S. . . . Sandbinding Plants (*Ind. For. xxxv, p. 82*).
- JACKSON, A. B. . . . Rate of Growth of Palmyras. (*Ind. For., xxxv, p. 394*).
- LUSHINGTON, A. W. . . . Some Notes on Palms. (*Ind. For., xxxv, p. 148*).
- MOLL, J. W. & Mikrographie des Holzes der auf Java vorkom-
JANESONIUS, H. H. menden Baumarten.
- SMITH, W. . . . The Anatomy of some Sapotaceous Seedlings.
(*Trans. Linn. Soc. vii, p. 189*).
- WITT, D. O. . . . Forest Flora of the Bérar Circle.
- WITT, D. O. . . . Germination and Development of *Hardwickia binata*, read at the Nagpur Forest Conference in November 1908.

SYLVICULTURE.

BY

R. S. TROUP, F.C.H.,

Imperial Sylviculturist and Superintendent of Forest Working Plans.

1. Investigations at the Imperial Forest Research Institute, Dehra Dun.

Investigations of a sylvicultural nature at the Imperial Forest Research Institute during the past year have of necessity been somewhat restricted. The post of Sylviculturist was practically held in abeyance till March 1908, when it was amalgamated with that of the Superintendent of Forest Working Plans. Almost the whole of the year under report was accordingly spent in the preliminary work of organising the details necessary for seriously taking up sylvicultural investigations.

In a subject like silviculture the chief disadvantage under which the investigator labours is the length of time which must usually elapse before any definite results become apparent, this period extending frequently to many decades of years. Accordingly much of the initial work connected with silvicultural research must consist for some time to come in starting experiments and recording observations which may lead to no definite and reliable results for many years. Work done hitherto in the Silvicultural and Working Plans branch of the Forest Research Institute has consisted chiefly of investigations into subjects connected with Working Plans; the various items of the past year's work are noted below.

2. Silvicultural Systems.

The selection system, owing to its simplicity when applied to the irregular forests of India, has hitherto been far more widely in vogue than any other system, the gradual improvement of the forests being effected *pari passu* by means of "improvement fellings".

The selection system as applied to India has recently been the subject of special study by Mr. A. M. F. Caccia, who has published an instructive note on the subject. This note reveals considerable diversity in the various methods of calculating the possibility: *i.e.*, the number of trees or quantity of timber that can properly be removed from a forest, and as local circumstances do not altogether warrant the extent of diversity which exists, and which under present conditions is likely to increase rather than to diminish, measures are desirable for systematising the various methods of calculating the possibility and, if possible, reducing their number.

Next to the selection system, including the execution of improvement fellings—which in themselves can hardly rank as a system—the coppice or coppice-with-standards systems have hitherto received most attention.

Of recent years it has become more and more apparent to Forest Officers that the almost universal application of the selection system in India is by no means desirable, for though the system, owing to its simplicity, is one which can be readily applied as a temporary measure to the natural forests of India, and in the absence of sufficient Silvicultural knowledge has in the past been the only system which could reasonably be applied in the majority

of cases, still the opinion is gaining ground that many types of forest in India are more adapted for working under what we may call the "uniform method." This term, although not altogether satisfactory, is perhaps the best general term to employ for the various methods already known or likely to be evolved in future, whereby an even aged naturally regenerated seedling crop is obtained by means of openings in the canopy of a high forest. The closely allied "group system" may here be included with the uniform method for convenience.

It is noteworthy that of 12 forest working-plans issued during the past year 2 prescribe working under the system of successive fellings; these are Mr. F. Trafford's working plan for the Singalila Range forests, Darjeeling, in which the species comprising the growing stock are *Michelia*, oaks, *Castanopsis*, laurels and various other species, and Mr. E. M. Coventry's working-plan for the Shillong pine forests (*Pinus Khasya*).

In Mr. Trafford's plan a rotation of 160 years is adopted, and the area is divided into 5 periodic blocks. Seed-fellings are to be carried out by groups or strips, and where advance growth is plentiful a complete clearing of the overwood is to be made.

In Mr. Coventry's working-plan for the Shillong pine forest a rotation of 60 years is fixed, the corresponding diameter being 2 feet. The rotation is divided into 4 periods of 15 years each. For the execution of regeneration fellings the first periodic block is divided into 5 annual coupes, the block being thus worked over three times during the period.

Proposals have also been put forward for the extension of the system to the *sál* forests of Kumaon in the United Provinces and the Mohnyin teak forests of Katha in Upper Burma, while negotiations are in progress for taking up a small tract of *sál* forest near Dehra Dun for the experimental application of the system under the supervision of the Imperial Forest Sylviculturist.

In the "Indian Forester" of September 1908, Mr. A. L. McIntire has an interesting article on the forests round Darjeeling, which have been regularly worked under the uniform method since 1892.

3. Information by Species.

A valuable contribution to the literature on *sál* (*Shorea robusta*) has been furnished by Mr. A. L. McIntire in his *Sál*,
"Notes on *Sál* in Bengal". This important

timber tree is receiving special attention at the Forest Research Institute, where investigations are in progress in connection with the elucidation of various sylvicultural problems connected with it.

In the "Indian Forester" of June 1909 Mr. L. S. Osmaston published some interesting notes on *Hardwickia binata* in the West Khandesh Division of the Bombay Presidency, particularly with regard to the coppicing power of the species. Actual measurements and enumerations show that neither the height at which the coppice is cut, nor the size of the stump, nor the rainfall of the years immediately preceding and succeeding the felling, have any decided effect on the vitality of the stumps.

A study of the more important Himalayan species was commenced by the Imperial Sylviculturist, the chief species concerned being deodar, *Pinus longifolia*, *Pinus excelsa*, *Picea Morinda*, *Abies Pindrow*, *Quercus dilatata* and *Quercus semecarpifolia*.

The compilation of statistical information in connection with naturally grown teak in Burma has been commenced: this information is based mainly on the results of working-plans enumerations carried out for nearly 30 years past in different types of teak forest in various parts of Burma.

In *Indian Forest Records, Vol. I, Part III*, Mr. B. B. Osmaston has a useful note on Andaman Padauk (*Pterocarpus dalbergioides* Roxb.), in which he draws attention to the lack of natural reproduction of that species under dense shade, and concludes, from the results of actual observations, that natural reproduction cannot be obtained in any abundance without making heavy clearings in the overwood. Such operations, however, are rendered somewhat difficult and expensive owing to the fact that padauk is not gregarious but scattered in mixed forest, and that most of the associate species are unsaleable.

Mr. Osmaston draws attention to the large proportion of mature and over-mature padauk trees, saplings and young poles as well as trees below 6 feet in girth being very scarce except in the neighbourhood of Port Blair, where clearings have admitted light: he concludes that this remarkable disparity in the age classes can be explained only by assuming that there has been a very recent change in the condition of the vegetation of the Andamans.

4. Yield Tables.

The collection of information for the compilation of yield tables has been commenced with respect to babul (*Acacia arabica*) in Berar, sissu (*Dalbergia Sissoo*) plantations at Changa Manga in the Punjab, eucalyptus plantations at Ostacamund, casuarina plantations in Madras and teak plantations at Nilambur in the Madras Presidency.

5. Information regarding Plantation Work.

A considerable amount of information was collected during the year on the subject of plantation work carried out in India on a large scale, particularly as regards agri-sylvicultural operations and the planting of arid lands and shifting sands. Short visits were paid to some of the more important of these works.

List of Indian Publications, 1908-09.

1. CACCIA, A. M. F. . A Glossary of Technical Terms for Use in Indian Forestry. (*Forest Pamphlet No. 3, 1908*).
2. CACCIA, A. M. F. . The Collection of Statistical Data relating to the Principal Indian Species. (*Forest Pamphlet No. 8, 1909*).
3. CACCIA, A. M. F. . The Selection System in Indian Forests as exemplified in Working-Plans based on this System, with a Short Description of Some Continental Methods. (*Ind. For. Rec., i, Pt. 4*).
4. CHANNER, F. F. R. The Forests of the Terai and Bhabar Government Estates, United Provinces. (*Ind. For., xxxiv, 393*).
5. CLUTTERBUCK, P.H. Revised Working-Plan for the Trans-Sarda Forests, Kheri Division, Eastern Circle, United Provinces.
6. COVENTRY, E. M. . Working-Plan for the Shillong Pine Forests, Eastern Bengal and Assam.
7. DUTT, SUKH LALL. . Light Burning and Natural Reproduction of Sal. (*Ind. For., xxxv, 154*).
8. JEFFERY, G. R. . Working-Plan for the Hintha, Ondok, and Kyauktaung reserves, Ruby Mines Division, Southern Circle, Upper Burma.

9. MARSDEN, R. E. . Working-Plan for the Kale Working Circle, Myittha Forest Division, Northern Circle, Upper Burma.
10. MCINTIRE, A. L. . Notes on Sál in Bengal. (*Forest Pamphlet No. 5, 1909*).
11. MCINTIRE, A. L. . The Regular Method of Treatment as applied to the Forests around Darjeeling. (*Ind. For., xxxiv, 519*).
12. MORGAN, V. G. . Working-Plan for the Motinala Range Forests, Mandla Division, Northern Circle, Central Provinces.
13. OSMASTON, B. B. . *Pterocarpus dalbergioides* Roxb. Andaman Padauk. (*Ind. For. Rec., i, Pt. iii*).
14. OSMASTON, L. S. . Some Plantations in Satara District of the Central Circle of Bombay. (*Ind. For., xxxiv, 533*).
15. OSMASTON, L. S. . Sylvicultural Notes on *Hardwickia binata*. (*Ind. For., xxxv, 377*).
16. PERRÉE, W. F. . Revised Working-Plan for the Goalpara Forest Division, Eastern Bengal and Assam.
17. POCKOCK, T. I. . Working-Plan for the Angul Forests, Bengal.
18. ROSS, A. E. . Working-Plan for the Lower Thaungyin Working Circle, Thaungyin Forest Division, Tenasserim Circle, Burma.
19. SOMERS-SMITH, C. . Working-Plan for the forests of the Saugor Division, Northern Circle, Central Provinces.
20. TRAFFORD, F. . Working-Plan for the forests of the Singalila Range, Darjeeling Division, Bengal.
21. TULLOCH, J. C. . Revised Working-Plan for the forests of the Bahraich Division, Eastern Circle, United Provinces.
22. WALKER, H. C. . Reproduction of Teak in Burma. (*Ind. For., xxxv, 367*).
23. WALSH, H. L. P. . Working-Plan for the Maingtha, Kunchaung, and Nanme Reserves, Ruby Mines Division, Southern Circle, Upper Burma.

FOREST PRODUCTS.

BY

R. S. PEARSON, F.L.S.,

Imperial Forest Economist.

The Imperial Forest Economist was engaged on investigating a variety of Forest Products of commercial value, his work to a great measure being confined to an enquiry into the uses of the more important Indian timbers. In this connection a large quantity of data was collected and a Forest Memoir published on the subject. Amongst other subjects to which special attention was paid was the possibility of creating a demand for timbers of value, but concerning which little is at present known by the public; the question of creating a demand for certain gums in the European market; the possibility of improving the prospects of the Match Industry in India, on which a treatise will shortly be published, giving information as to woods which have been found suitable for matches, the yield of suitable timber in given localities, possible sites for match factories, and the financial aspect of the business; experiments were commenced with respect to the antiseptic treatment of Indian timbers by different methods, especially with a view of determining the possibility of increasing the durability of inferior woods which are otherwise unsuited for railway sleepers; many minor enquiries were started, generally at the instance of Indian firms, as to the use of certain timbers for such articles as lead pencils, cricket bats, pipes, tea boxes, opium chests and a variety of similar goods.

Strength and Fissibility Tests of Indian Timbers.—Tests as to the tranverse strength of certain timbers were carried out at Sibpur Engineering College, but the progress made was slow. The object of the tests was to determine the strength of the timbers concerning which little is known by the public, but for which it is hoped a demand may in time arise. Another set of tests are being carried out to ascertain the relative strength of plantation and natural grown teak in Burma.

Experiments as to the fissibility of timber when split in a green and seasoned condition, as also when split radially and tangentially, were carried out in the Research workshops. An interesting feature of the results obtained was that whereas the generally accepted theory in Europe is that timber splits more easily radially than tangentially the reverse was found to be the case with most Indian timbers.

Antiseptic Treatment of woods.—The importance of attempting to utilize the softer and more perishable species found in the Indian forests especially with the ever increasing prices of the more valuable timbers, continued to receive attention. Several methods of treating timber have been brought forward in the past and have attained considerable success. They require, for the most part, a considerable initial outlay on the necessary plant, and this has no doubt led to the appearance on the market of certain antiseptic solutions which can be applied externally and without any great initial outlay. Of the more recent preservative methods may be mentioned the Powellizing process. By the courtesy of the Indian Agents for this process Messrs. Killick Nixon & Co., of Bombay, it was possible to procure and lay down a large number of powellized specimens of Indian timbers together with untreated specimens and keep them under observation.

Under antiseptic solutions which are applied like paint; but in a hot state, specimens were treated with four different solutions, and together with untreated specimens laid down and put under observation. Of the four above mentioned solutions, one, namely, "Avenarius Carbolinum," has undergone a severe laboratory test at the National Forest School at Nancy, France, and so favourable were the results obtained that a railway company in France has laid down a large number of sleepers treated with this solution. The whole question of preserving wood, particularly for railway sleepers, is under investigation.

Seasoning of Timber.—Experiments as to the seasoning of timber, both naturally and artificially treated, were carried out, and information collected as to their relative warping propensities when freshly sawn. Species of timber which are known to contract star and cup-shake while seasoning were treated with a solution known on the market as "Ligno," and placed under observation together with untreated logs. It is as yet not possible to state what advantages are derived by such a treatment, but as far as can now be judged the experiment should prove instructive.

Wood and Bamboo Pulp.—The progress made in India, in starting the industry with raw material obtained from forests, has advanced but slowly. Following his investigations into the value of bamboo for paper pulp, Mr. Sindall carried out experiments during the year to ascertain the value of the wood of Himalayan silver and spruce. The results obtained by him were sufficiently encouraging to make it desirable to carry out experiments to ascertain the cost of exploiting the timber from the hills, and Jaunsar Division, in the United Provinces, was selected as

a likely site for the operations. Mr. Billson, the Divisional Forest Officer, supervised the work, but the first attempt has shown the cost to be prohibitive.

Attention is being directed to the possibility of the sulphite process being used with advantage in the manufacture of bamboo pulp, and experiments in this connection are being undertaken. The possibility of starting paper-pulp manufacture in India and Burma is under investigation.

The Match Industry.—This industry has received a considerable amount of attention in India of late years, while the enquiries as to the possibility of starting factories in various parts of India have been numerous. Forty species of Indian timbers were sent to Europe in the previous year, to be tested, and a full report as to their value is now available. A full report on the subject, together with complete estimates for a fully equipped factory estimating the profit and loss on such an undertaking, is now in the press, and should shortly be available to the public.

Oil-seeds.—The question of utilizing the oil expressed from the seeds of forest trees for edible and burning purposes, as also for soap-making and oil-cake, was under investigation. At the instance of Mr. A. G. Lowrie, a forest officer in the Central Provinces, oil expressed from the seed of *Schleichera trijuga* was sent to an Indian firm with a view of utilizing it for soap-making, while the seed of *Prunus eburnea*, on analysis in England, has been classed as a possible substitute for almond oil. The question of utilizing seeds of certain forest trees for oil-cake and manure will be further examined.

Tans and Dyes.—An article entitled "The use of *Terminalia Arjuna* bark for Tanning," by D. O. Witt, I.F.S., brings to notice the use of the "Kohar" bark as a tanning agent, in the Nimar division of the Central Provinces. The process employed locally, in tanning leather with the aid of the bark, is to subject the hide to soaking in water to which some 30 seers of bark are added, and leaving it in the solution for six days. The importance of Mr. Witt's article is not the method of tanning the leather, but the use of the bark of *Terminalia Arjuna*.

Botanical and other specimens.—A large number of botanical specimens as well as specimens of wood, samples of seed and minor forest products, were collected by the Forest Department and supplied to the Reporter on Economic Products, Imperial Forest Research Institute, Agricultural Research Institute, Pusa, America, Chilli, Austria, Phillippines and private firms in India and abroad.

Publications.—Several publications dealing with economic subjects were sent to the press, but have not been published up to date.

Of the publications on forest matters, Economic Branch, the following are the most noteworthy :—

List of Publications.

1. COVENTRY, E. M. . Notes on the Principal Timber Trees of Eastern Bengal and Assam.
2. GUPTA, J. N. . A Monograph on Paper Making and Papier Maché in Eastern Bengal and Assam.
3. HENRY, E. . Essai en Grand du " Carbolineum Avenarius " (*Revue des Eaux et Forêts* No. 7, 1st April 1909).
4. LOWRIE, A. E. . The Propagation and Collection of Lac.
5. PURAN SINGH . A note on the Manufacture of Pure Shellac, (*Ind. For. Mem., i, Chem. Ser. Pt. ii*).
6. TROUP, R. S. . A note on the Present Position and Future Prospects of the Cutch Trade in Burma. (*Ind. For. Rec., i, Pt., iii*).
7. TROUP, R. S. . Note on the Andaman Marble wood or Zebra wood, *Diospyros Kurzii*. (*Forest Pamphlet No. VII, For. Econ. Ser. No. II*).
8. TROUP, R. S. . Indian Woods and their uses. (*Ind. For. Mem. i, Econ. Prod. Ser. No. I*).
9. WITT, D. O. . A note on the use of *Terminalia Arjuna* Bark (*Ind. For., xxxiv, No. x, October 1908*).

INDIAN ZOOLOGY.

October, 1908—September, 1909.

BY

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Superintendent, Indian Museum.

This report, as heretofore, consists mainly of an account of the zoological research undertaken in connection with the Natural History

Section of the Indian Museum during the year, but includes also a brief summary of what has been accomplished elsewhere in India and abroad. As only work that directly affects the Indian Empire is dealt with, no further mention need be made of the valuable researches on the zoology of Ceylon undertaken by the Colombo Museum. An account of these researches will be found in the periodical *Spolia Zeylanica* issued by the Colombo Museum.

I.—Work done by the Indian Museum.

(a) **Field Work.**—It is perhaps as well that in this report special stress should be laid on work of direct “practical” importance, and more than a reference may therefore be omitted as regards the collections made of organisms such as sponges, Neuroptera and lizards, although in all these groups they have been considerable. Attention may, however, be invited to what has been done as regards collecting Diptera and fish, as both these groups are of recognized economic importance.

Among the mosquitoes collected last year in various parts of India by the staff of the Museum, Mr. F. Theobald, who has been kind enough to submit a report on the specimens, has found the “types” of twenty-three new species, among which are those of four new genera; while of the allied blood-sucking genus *Phlebotomus* we have acquired specimens of seven Indian species, on which, in collaboration with Mr. F. M. Howlett, Second Imperial Entomologist, I hope shortly to publish a report. One of these species has been proved to transmit a certain type of fever in Southern Europe. The Indian blood-sucking Muscidae in the collection have now become sufficiently numerous to form the basis of a report by Mr. E. Brunetti which is already almost finished. An interesting new genus is described, as well as several new species. Arrangements have also been made for the publication of a series of monographs on the Oriental representatives of other blood-sucking families of Diptera by specialists to whom our collections have been distributed, and also of one on the Trypetidae or fruit-flies. That on the Chironomidae (including the blood-sucking species of the sub-family Ceratopogoninae) is by Professor Kieffer of Bitsch in Germany and has already been received. It includes descriptions of 35 Indian species of Ceratopogoninae, all of which are new to science.

As regards fish, it has been found that much of the work of the older Indian ichthyologists needs revision, and that to carry out a revision it is necessary to make fresh collections even of the common species. We have therefore made arrangements to obtain specimens from Karachi and elsewhere as well as collecting them ourselves wherever an opportunity has occurred. In this work we have been fortunate in obtaining the assistance of Dr. J. Travis Jenkins, Scientific Adviser on Fisheries to the Government of Bengal. It is much to be regretted from a "practical" as well as a purely scientific point of view that no arrangements have been made officially for ichthyological research in connection with the Government of Bengal's fishery steamer "Golden Crown," but the Museum, with the active co-operation of the Scientific Adviser, has done what was possible to remedy this omission, and latterly our zoological collector has gone out on the vessel to preserve specimens as they are caught. By all these means a large collection of both marine and freshwater species has been accumulated. We hope that, with subsequent additions, it may form the basis of a complete revision of the fish fauna of India.

(b) —Work in the laboratory.—Considering first work as regards terrestrial zoology, I may note the completion and publication of Captain R. E. Lloyd's *Research on Terrestrial Zoology*. researches on Indian rats, so far as work of the kind can be completed in a couple of years. The importance of this work was noted in last year's report. Mr. E. Brunetti, in addition to his work on blood-sucking Muscidæ, has finished his revision of the Oriental Leptidæ, Bombylidæ and Sepsinæ, and has already found it necessary, owing to additional collections that have been obtained, to write a supplement on the first two families. He has also made considerable progress on a monograph of the Indian Tipulidæ (crane-flies), the extreme fragility of specimens of which has rendered them very scarce in most collections. They are, however, well represented in that of the Indian Museum, and nearly a hundred new species will have to be described. In collaboration with Dr. Walther Horn of Berlin, or rather compiling information from his work, I have prepared for publication an annotated list of Cicindelinae (Tiger-beetles) in our collection in the hope that it may form the first part of a catalogue of the Coleoptera of the Indian Museum, a work that would be of use to students of zoogeography.

The work of examining and describing the freshwater invertebrates of India and Burma has continued to occupy much of my attention, and I hope shortly to be in a position to publish an account of the Phylactolæmatous and other Polyzoa that occur in stagnant water in the Oriental Region. Mr. B. L. Chaudhuri, Assistant Superintendent in the Museum, besides describing several new species of fish from the "Golden Crown" collection, has commenced a revision of the Indian Cobitidæ or Loaches.

**Research on the Freshwater
Fauna of India.**

As regards marine zoology progress has been made: Captain F. H. Stewart, Surgeon Naturalist, Indian Marine Survey, has worked in the Museum for some months at the "Investigator" collection of Polychæte worms and has commenced an investigation, which promises to have interesting results, into the morphology and development of the degenerate males of certain barnacles. The barnacles have also formed the basis of a systematic monograph, of which the first part has recently been published in the "Memoirs of the Indian Museum." Marine ichthyology has not been confined to the collection of specimens, for Captain R. E. Lloyd has published an account of the deep-sea fish obtained by the "Investigator" since the publication of Colonel Alcock's monograph in 1899 and has added some interesting observations on variation in one of the genera, while I have myself published an account of the Rays taken by the "Golden Crown." Dr. Jenkins and Mr. Chaudhuri have devoted much time and patience to preliminary work on the other groups in the collection presented by the Commissioner of Fisheries, Bengal.

Research on Marine Zoology.

II.—Work done in India apart from the Museum.

The only zoological work issued officially during the year from any of the Indian colleges is the volume on "Indian Insect Life" written by Messrs. Maxwell-Lefroy and Howlett, of the Pusa Agricultural College. Major J. Stephenson, of the Government College, Lahore, has published a paper on some Oligochaete worms collected by Captain Stewart in Tibet (*Rec. Ind. Mus.*, iii), while Dr. Imms of the Muir College, Allahabad, has described in the *Journ. Linn. Soc. London*, a minute centipede from the Himalayas. Captain R. E. Lloyd, now acting as Professor of Biology in the Medical College, Calcutta, has

**Zoological Research in the
Indian Colleges.**

written a paper on the relation between normality and fertility in rats which will shortly be published in the *Rec. Ind. Mus.*

Several short notes on medical zoology by doctors in India will be found scattered in medical journals, while

Indian Medical Zoology.

Captain W. S. Patton and Capt. R. McCarri-son of the Indian Medical Service have published longer papers on Protozoon parasites in English and German periodicals to which full reference will be found in the bibliography attached to this report.

The Bombay Natural History Society continues to prove its vigour by the excellence of its publications, while

**Zoological work of Indian
Learned Societies.**

the Asiatic Society of Bengal has published a monograph of the sea-snakes of the world by Major F. Wall, I.M.S. A project is also on foot to issue reproductions of the valuable series of original drawings of Indian fish in the library of the latter Society.

III.—Work in Europe and America.

The work on Indian Zoology undertaken during the year in Europe and America consists, so far as published records indicate, mainly of descriptions of new species based on specimens sent from India. The only comprehensive monographs that deal specifically with the Indian Fauna are the fourth volume of Mr. W. L. Distant's account of the bugs in the "Fauna of British India" series, and Colonel C. Swinhoe's continuation of Moore's *Lepidoptera Indica*.

The fact that the former volume consists largely of an appendix

**The "Fauna of British
India."**

on species of which descriptions were not included in the previous three volumes, and that at least one additional volume of a similar nature is to be issued, illustrates the paucity of our actual knowledge of the less conspicuous elements in the fauna of India and the rate at which this knowledge is expanding.

*List of the papers and books having a special reference to Indian
Zoology recently published.*

Memoirs published in India.

In the *Memoirs of the Indian Museum*. The Oligochæta of India, Nepal, Ceylon, Burma and the Andaman Islands. By Dr. W. Michaëlsen. Vol. i, 1909, p. 103.

The Anatomy of some aquatic Oligochæta from the Punjab. By Major J. Stephenson, I.M.S. *Ibid.*, p. 255.

Investigator sicarius, a Gephyrean worm hitherto undescribed, the type of a new order. By Captain F. H. Stewart, M.A., D.Sc., M.B., I.M.S. *Ibid.*, p. 283.

Report on the fishes taken by the Bengal Fisheries steamer "Golden Crown." Part i—Batoidei. By N. Annandale, D.Sc. Vol. ii, 1909, p. 1.

An account of the Indian Cirripedia Pedunculata. Part i—Family Lepadidæ (*sensu stricto*). By N. Annandale, D.Sc. *Ibid.*, p. 61.

A Description of the Deep-Sea Fish caught by the R.I.M.S. ship "Investigator" since the year 1900, with supposed evidence of mutation in *Malthopsis*. By Captain R. E. Lloyd, M.B., D.Sc., I.M.S. *Ibid.*, p. 139.

In the *Records of the Indian Museum*. Report on a collection of Aquatic Animals made in Tibet by Captain F. H. Stewart, I.M.S., during the year 1907. Part i—Introduction, Coelenterates, Nematomorpha, Rotifers and Gastrotricha, Entomostraca, Arachnids, Fish (Systematic) and Batrachia. By Captain F. H. Stewart, M.A., D.Sc., N. Annandale, D.Sc., Dr. J. G. deMan, L. Camerano, E. von Daday, Captain R. E. Lloyd, M.B., D.Sc., I.M.S. Vol. ii, 1908-1909, p. 309.

Notes on Aculeate Hymenoptera in the Indian Museum. By Colonel C. T. Bingham. *Ibid.*, p. 347.

Indian Psychodidæ. By E. Brunetti. *Ibid.*, p. 369.

Description of a new species of mouse from the Madura District, Madras. By T. Bentham. *Ibid.*, p. 385.

Some Cleridæ of the Indian Museum. By S. Schenkling. *Ibid.*, p. 387.

Description of a new species of Polychæte worm of the Genus *Spio*. By A. Willey, D.Sc., F.R.S. *Ibid.*, p. 389.

Description of a new species of saw-fish captured off the Burma Coast by the Government of Bengal's Steam Trawler "Golden Crown." By B. L. Chaudhuri. *Ibid.*, p. 391.

A new Sting Ray of the Genus *Trygon* from the Bay of Bengal. By N. Annandale, D.Sc. *Ibid.*, p. 393.

New Micro-Lepidoptera from India and Burma. By E. Meyrick, B.A., F.R.S. *Ibid.*, p. 395.

Notes on some Chrysomelid Beetles in the collection of the Indian Museum. By C. A. Paiva. *Ibid.*, p. 401.

Six new Cicindelinae from the Oriental Region. By Dr. Walther Horn. *Ibid.*, p. 409.

Description of an *Agriolimax* from Gyantse, Tibet, collected by Captain F. H. Stewart, I.M.S., with details of its anatomy. By Lieut.-Col. H. H. Godwin-Austen, F.R.S., F.Z.S. *Ibid.*, p. 413.

Revision of the Oriental Leptidæ. By E. Brunetti. *Ibid.*, p. 417.

Revised and Annotated Catalogue of Oriental Bombylidæ with descriptions of new species. By E. Brunetti. *Ibid.*, p. 437.

The Races of Indian Rats. By Captain R. E. Lloyd, M.B., D.Sc., I.M.S. Vol. iii, 1909, p. 1.

Notes on Freshwater Sponges, No. 10. Report on a small collection from Travancore. By N. Annandale, D.Sc. *Ibid.*, p. 101.

Report on a collection of aquatic animals made in Tibet by Captain F. H. Stewart, I.M.S., during the year 1907. Part. ii. Oligochæte worms, Mollusca and Fish (Geographical). By Major J. Stephenson, I.M.S., H. B. Preston, L. Germain and Captain F. H. Stewart. *Ibid.*, p. 105.

Note on some Amphibious Cockroaches. By R. Shelford, M.A., F.L.S. *Ibid.*, p. 125.

Description de quelques nouvelles Cécidomyies des Indes. By Professor J. J. Kieffer. *Ibid.*, p. 129.

Description of new land and marine shells from Ceylon and S. India. By H. B. Preston, F.Z.S. *Ibid.*, p. 133.

Description of two new species of *Caranx* from the Bay of Bengal. By E. L. Chaudhuri, B.Sc. *Ibid.*, p. 141.

Remarks on some little known Indian Ophidia. By Major F. Wall, I.M.S., C.M.Z.S. *Ibid.*, p. 145.

Remarks on some forms of *Dipsadomorphus*. By Major F. Wall, I.M.S., C.M.Z.S. *Ibid.*, p. 151.

A Pelagic Sea-Anemone without tentacles. By N. Annandale, D.Sc. *Ibid.*, p. 157.

Rhynchota Malayana. Part II. By W. L. Distant. *Ibid.*, p. 163.

Occasional Publications of the Indian Museum. Echinoderma of the Indian Museum: Deep-sea Asteroidea collected by the R. I. M. S. "Investigator." By R. Koehler.

An Illustrated Catalogue of the Asiatic Horns and Antlers in the collection of the Indian Museum. By T. Bentham.

In the *Memoirs of the Asiatic Society of Bengal.* A monograph of the sea snakes. By Major F. Wall, I.M.S., C.M.Z.S. Vol. ii, 1909, p. 169.

A Polyglot List of Birds in Turki, Manchu and Chinese. By E. Denison Ross, Ph.D. *Ibid.*, p. 253.

In the *Journal and Proceedings of the Asiatic Society of Bengal*. Note on the Peregrine Falcon (*Falco peregrinus*). By Lieut.-Col. D. C. Phillott. Vol. iv, 1908, p. 259.

Diagnosis of a living species of the Genus *Diplonema* (Psychodid Diptera). By N. Annandale, D.Sc. *Ibid.*, p. 353.

In the *Journal of the Bombay Natural History Society*. A Popular Treatise on the Common Indian Snakes. Parts viii—x. By Major F. Wall, I.M.S., C.M.Z.S. Vol. xviii, 1908, p. 711, and Vol. xix, 1909, pp. 87, 287.

Notes on the Classification of the Bandicoots. By R. C. Wroughton. Vol. xviii, 1908, p. 736.

Important additions to the Indian Avifauna. By E. C. Stuart Baker, F.L.S., F.Z.S. *Ibid.*, p. 753.

Remarks on some recently acquired snakes. By Major F. Wall, I.M.S., C.M.Z.S. *Ibid.*, p. 778.

A new Pit Viper of the Genus *Ancistrodon*. By Major F. Wall, I.M.S., C.M.Z.S. *Ibid.*, p. 792.

Descriptions of Indian Micro-Lepidoptera. Parts viii and ix. By E. Meyrick, F.R.S. *Ibid.*, p. 806, and Vol. xix, 1909, p. 410.

Insect Life in India and how to study it. By E. P. Stebbing. *Ibid.*, p. 862.

An India Stoat. By R. C. Wroughton. *Ibid.*, p. 882.

Further notes on the Butterflies of the Konkan. By G. W. V. de Rhé-Philipe. *Ibid.*, p. 884.

On a new species of Bush-Quail (*Microperdix*) from Goalpara, Assam. By W. R. Ogilvie-Grant with field notes by C. M. Inglis. Vol. xix, 1909, p. 1.

The Kathiawar Lion. By Lieut.-Col. L. L. Fenton. *Ibid.*, p. 4.

The common Butterflies of the Plains of India, including those met with in the Hill Stations of the Bombay Presidency. By T. R. Bell, I.F.S. *Ibid.*, pp. 16, 438.

A List of the Birds of the Bhamo District, Upper Burma. By Major H. H. Harington. *Ibid.*, pp. 107, 299.

On some undescribed Bees and Wasps captured by Lieut.-Col. C. G. Nurse in India. By P. Cameron. *Ibid.*, p. 129.

Bird notes from Murree and the Galis. By Major H. A. F. Magrath. *Ibid.*, p. 142.

Biological Notes on Oriental Hemiptera, Nos. 2-3. By J. C. Kershaw and G. W. Kirkaldy. *Ibid.*, pp. 177, 333.

Measurements of some of the Horns in the collection of the Bombay Natural History Society. By N. B. Kinnear. *Ibid.*, p. 184.

Notes on Snakes from the neighbourhood of Darjeeling. By Major F. Wall, I.M.S., C.M.Z.S. *Ibid.*, p. 337.

Some Rangoon Birds. By Major H. H. Harington. *Ibid.*, p. 358.

The Nesting of the Bar-Headed Goose (*Anser indicus*) in Tibet. By F. M. Bailey. *Ibid.*, p. 367.

Some Nature Notes. By Lieut.-Col. R. G. Burton. *Ibid.*, p. 399.

The Preservation of Natural History Specimens in Airtight Cases. By John Wallace, C.E. *Ibid.*, p. 502.

New and Little Known Indian Hymenoptera. By Lieut.-Col. C. G. Nurse. *Ibid.*, p. 510.

Memoirs published in Europe and America.

In the *Annals and Magazine of Natural History*. A new squirrel from Burmah. By R. C. Wroughton. Series 8, Vol. ii, 1908, p. 491.

New Species of Indo-Malayan and African Lepidoptera. By Colonel C. Swinhoe, M.A., F.E.S. Series 8, Vol. iii, 1909, p. 89.

New Genera and Species of Blood-sucking Muscidæ from the Ethiopian and Oriental Regions, in the British Museum (Natural History). By E. E. Austen. *Ibid.*, p. 285.

Rhynchotal Notes. By W. L. Distant. *Ibid.*, p. 317.

Alcyonarians from the Gulf of Cutch. By Professor J. Arthur Thomson and George Crane, B.Sc. *Ibid.*, p. 362.

The Genus *Puerulus*, Ortmann, and the Post-larval Development of the spiny Lobsters (Palinuridæ). By W. T. Calman, D.Sc. *Ibid.*, p. 441.

Remarks on some Genera of the Scoliidæ, with descriptions of new species. By R. E. Turner, F.Z.S., F.E.S. *Ibid.*, p. 476.

Four new Tabanus Species from India and Assam. By Gertrude Ricardo. *Ibid.*, p. 487.

Oriental Rhynchota Heteroptera. By W. L. Distant. *Ibid.*, p. 491.

New Species and Varieties of Hydroida Thecata from the Andaman Islands. By J. Ritchie, M.A., B.Sc. *Ibid.*, p. 524.

Rhynchotal Notes. By W. L. Distant. Ser. 8, Vol. iv, 1909, p. 73.

Four new Lamellicorn Coleoptera from the Oriental Region. By G. J. Arrow. *Ibid.*, p. 91.

Systematic notes on Coleoptera of the Clavicorn Families. By G. J. Arrow. *Ibid.*, p. 190.

Descriptions of apparently new species and subspecies of monkeys of the Genera Callicebus, Lagothrix, Papio, Pithecus, Cercopithecus, Erythrocebus, and Presbytis. By D. G. Elliot, D.Sc., F.R.S.E. *Ibid.*, p. 244.

In the *Proceedings of the Zoological Society of London*. Two new genera (and a new species) of Indian Lycænids. By T. A. Chapman, M.D. 1908, p. 676.

The Sze-chuen and Bhutan Takins. By R. Lydekker, B.A., F.R.S. *Ibid.*, p. 795.

On an Indian Dolphin and Porpoise. By R. Lydekker, B.A., F.R.S. *Ibid.*, p. 802.

An Unknown Lemur from the Lushai Hills, Assam. By N. Annandale, D.Sc. *Ibid.*, p. 888.

Contributions to the Anatomy of certain Ungulata, including *Tapirus*, *Hyrax*, and *Antilocapra*. By F. E. Beddard, M.A., F.R.S. 1909, p. 160.

In the *Journal of the Linnean Society of London*. On a new species of *Symphyla* from the Himalayas. By A. D. Imms, B.A., D.Sc. Vol. xxx, 1909, p. 252.

In the *Transactions of the Linnean Society of London*. On some new Alcyonaria from the Indian and Pacific Oceans, with a discussion of the Genera *Spongodes*, *Siphonogorgia*, *Chironephthya*, and *Solenocaulon*. By Ruth M. Harrison. With a Prefatory note, by Professor G. C. Bourne, M.A., D.Sc. Series 2, Vol. xi, 1909, p. 17.

The Madreporarian Corals collected by the Percy Sladen Trust Expedition to the Indian Ocean in 1905. By J. Stanley Gardiner, M.A., F.R.S. Series 2, Vol. xii, 1909, p. 257.

Antipatharia. By C. Forster Cooper, M.A. *Ibid.*, p. 301.

Amphipoda Gammaridea from the Indian Ocean, British East Africa, and the Red Sea. By A. O. Walker, F.L.S., F.Z.S. *Ibid.*, p. 323.

The Stylasterina of the Indian Ocean. By S. J. Hickson, F.R.S., and Helen M. England, M.Sc. *Ibid.*, p. 345.

Polychæta of the Indian Ocean. Part i. The Amphinomidæ By F. A. Potts, M.A. *Ibid.*, p. 355.

In the *Ibis*. On the Birds of Kohat and Kurram, Northern India. By Lieut. C. H. T. Whitehead, I.A., with an Introduction by Major H. A. F. Magrath, I.A. Series 9, Vol. iii, 1909, pp. 90, 214.

Field notes on Vultures and Eagles. By Brigadier-General H. R. Kelham, C.B. *Ibid.*, p. 413.

On the Tail-Feathers of the Dabchick. By W. P. Pycraft, F.Z.S. *Ibid.*, p. 469.

In the *Proceedings of the Malacological Society of London*. The Dispersal of Land Shells by the agency of man. By Lieut.-Col. H. H. Godwin-Austen, F.R.S. Vol. viii, 1908, p. 146.

In the *Quarterly Journal of Microscopical Science*. Studies on Ceylon Hæmatozoa. No. 1. The Life Cycle of Trypanosoma Vittatæ. By Muriel Robertson, M.A. New Series, Vol. liii, 1909, p. 665.

Observations on the Amœbæ in the Intestines of Persons suffering from Goitre in Gilgit. By R. McCarrison, M.D. *Ibid.*, p. 723.

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In the *Bulletin of the Biological Survey of the U. S. Department of Agriculture*. The Brown Rat in the United States. By David E. Lantz. No. 33, 1909.

In *Notes from the Leyden Museum*. Etude sur les Colobicus vrais de l'Europe, de l'Asie et de l'Australie par A. Grouvelle. Vol. xxx, 1908-1909, p. 113.

A new and curious Burmese Ascalaphid from the Genoa Museum (*Glyptobasis spinicornis*). By Dr. H. W. van der Weele. *Ibid.*, p. 245.

New Genera and Species of Megaloptera Latr. By Dr. H. W. van der Weele. *Ibid.*, p. 249.

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Notes sur quelques Élaterides Exotiques. Par C. Szombathy. *Ibid.*, p. 118.

Noch Einiges über die Dipterengattung Loxoneura Macq. Von Dr. K. Kertész. *Ibid.*, p. 337.

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In the *Natuur Kundig Tijdschrift voor Ned.-Indië*. Beitrag zur Kenntnis der Amphibien-larven des Indischen Archipels. Von Dr. P. N. van Kampen. Vol. lxix, 1909, p. 25.

In the *Nachrichtenblatt der Deutschen Malakozoologischen Gesellschaft*. Diagnosen neuer Vivipara-Formen. Von W. Kobelt. Vol. xl, 1908, p. 161.

In the *Zoologische Jahrbücher*. Synopsis der rezenten Schildkröten, mit Berücksichtigung der in historischer Zeit ausgestorbenen Arten. Von F. Siebenrock. Suppl. x, 1909, p. 427.

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Ein Beitrag zur Dipteren-Fauna des westlichen Himalaya. Von B. Lichtwardt. *Ibid.*, p. 123.

On three new species of Evaniidæ from the Oriental Zoological Region. By P. Cameron. *Ibid.*, p. 660.

Beitrag zur Kenntnis der Nemestriniden. Von B. Lichtwardt. *Ibid.*, p. 643.

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Enumeratio Pentatomidarum post Catalogum bruxellensem descriptarum. Conscripsit E. Bergroth. *Ibid.*, p. 131.

In the *Wiener Entomologische Zeitung*. Intorno a due Gryllacris di Birmania. Pel Dr. Achille Griffini. Vol. xxvii, 1908, p. 205.

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Diagnoses de Lycides nouveaux ou peu connus. Par J. Bourgeois. *Ibid.*, p. 501.

In the *Entomologisches Vereinsblatt. Beilage zur Entomologischen Rundschau*. Sodann spricht Horn über die Faunistik der indischen Cicindelinen. 26 Jahrgang, Nr. 7, 1909, p. 13.

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Rhynchota (Homoptera). Vol. iv, pt. 2. By W. L. Distant.

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Ticks: A monograph of the Ixodoidea. By G. H. F. Nuttall, C. Warburton, W. F. Cooper and L. E. Robinson.

Lepidoptera Indica, pt. lxxviii. By Colonel C. Swinhoe.

Official Report on Fruit and other Pests in various countries, 1907-1908. By W. W. Froggatt. Sydney.

Collections Zoologiques du Baron Edm. de Sélys Longchamps. Catalogue Systématique et descriptif. Fasc. VIII, IX, XIX and XX.

Systematisches Conchylien-Cabinet von Martini und Chemnitz. Vol. i, pts. 221—224, 1908, and pts. 225—228, 1909. The making of species by D. Dewar and Frank Finn. London, 1909.

NOTE.—In addition to the papers referred to in the above list many short miscellaneous notes on Indian zoology will be found in the *Records of the Indian Museum* and the *Journal of the Bombay Natural History Society*. Papers referring solely to Ceylon are not noticed, but several that have a more or less direct bearing on the zoology of India will be found in *Spolia Zeylanica*, the organ of the Colombo Museum.

AGRICULTURAL ENTOMOLOGY.

BY

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Imperial Entomologist.

The study of the insect pests of crops was continued at the Pusa Research Institute and by the assistants in Provincial Agricultural Departments. The detailed study of the more important species was carried on in the insectory, on the Pusa experimental farm, and in the field. The work against potato-moth (*Phthorimæa operculella*) was extended into

Bengal, the Central Provinces and Bombay, and larger trials are being made of methods of storage. Further study was made of the ground-nut leaf-miner (*Anacampsis nerteria*) and rice stem-borer (*Schœnobius bipunctifer*) in Madras. In Bombay the work of checking the Rice Grass-hopper (*Hieroglyphus furcifer*) has been successful and work is being undertaken against the Deccan grass-hopper, a wingless species new to science which has lately come into prominence. In the United Provinces, work has been done in checking the Rice Grass-hopper (*Hieroglyphus furcifer*) attacking sugarcane. For a very large number of pests, further information has been accumulated, specially with regard to their seasonal occurrence and to the peculiarities of their distribution in the various agricultural areas of India.

The work of testing insecticides has been concluded for the moment; a new insecticide, to replace arsenicals, has been found and is being put on sale and generally rendered available. The attempt to find good commercial insecticides that could be sold by makers has been abandoned and arrangements have been made to render available a small number of standard preparations to meet all needs. In particular, the attempt to find any contact poison superior to Crude Oil Emulsion, introduced into India in 1903 by the Agricultural Department, has failed and this insecticide is now established.

A feature of the year has been the attention paid to the eri silk industry, which is being very largely tried at the present time. Practically all experimental work in this has ceased and at Pusa the work is confined to carrying on the industry with a view to training those who wish to embark upon it as an industry. The possibilities of mulberry silk are being investigated, as also of tasar and other wild silks. In these cases it is the commercial possibilities rather than the scientific aspects that are being considered and the purely practical work of the section at Pusa has increased so much that purely scientific enquiry must take a minor place. The Supernumerary Entomologist, Mr. C. W. Mason, has continued his enquiry on the food of birds and has also been in charge of an inquiry to determine how far dessication of wheat protects it from weevil.

Lac cultivation has been continued at Pusa to afford a training in it rather than to apply scientific research, but this work has brought out forcibly the need there is of a scientific enquiry, carried on over a long time, into the races of the lac insect, of which very little is known at all.

The number of enquiries received at Pusa from all parts of India has been very large and the minor inquiries they give rise to are consider-

able. An investigation into the deterioration of Army mobilisation clothing by *Anthrenus vorax* was made by the Supernumerary Entomologist, Mr. C. W. Mason.

The Second Imperial Entomologist, Mr. F. M. Howlett, B.A., has continued his investigations into *Diptera* which attack fruit and crops and those which attack cattle. The life histories of flies that cause damage to crops have been worked out and the very difficult question of fruit flies and their parasites enquired into.

In South India, Mr. R. D. Anstead, Scientific Officer of the U. P., A. S. I., has taken up the question of the scale insects attacking coffee (*Lecanium hesperidum* and *L. hemisphaericum*).

Mr. C. B. Antram, Entomologist to the Indian Tea Association, has confined his attention to the investigation of the Tea Mosquito (*Helopeltis theivora*) and the Tea Green Fly (*Chlorita flavescens*); in connection with the former, extensive experiments are being carried out on gardens throughout the tea districts. Experiments in spraying for checking the Thrips on Tea in Darjeeling, were made by the Imperial Entomologist at Lebong.

An advanced course of teaching in agricultural entomology is now given at Pusa to graduates from Agricultural Colleges, the course occupying one year; to the students taking the course in general agriculture at Pusa, a shorter course of instruction in practical entomology is given. In connection with the former the publication of Indian Insect Life, which took place in August, deserves mention; this volume of 780 pages is a manual of the insects of the plains of India, based upon the lectures given to students of Agricultural Entomology at Pusa and intended for them, as for entomologists in general. Indian Insect Pests has been translated into Bengali and the translation is being published.

The scope of this report is confined to Agricultural Entomology and all reference to the purely scientific work of the Pusa Institute, a necessary corollary of teaching, is omitted. The record of advance is smaller than in previous years and there is especially little to record in publications; but, in this subject, the scientific work of previous years is bearing fruit in greatly increased applied work, and, failing an adequate increase of workers to do the practical work, those doing scientific enquiry must abandon it.

Publications.*Indian Tea Association*

BULL. NO. 2, 1909—

C. B. ANTRAM . Mosquito Blight—Report on Experiments during season 1908 at Rampore and Koombergram Tea Estates.

C. B. ANTRAM . Mantis Insects predaceous on the Tea Mosquito.

Memoirs, Department of Agriculture.

VOL. II, NO. 7, H. MAXWELL-LEFROY . Notes on Coccidæ.

Journal Articles.

VOL. IV, NO. 2, H. MAXWELL-LEFROY . Eri or Castor Silk.

VOL. IV, NO. 3, H. MAXWELL-LEFROY . Lac as an Agricultural Industry.

Thrips on Tea in Darjeeling.

FOREST ZOOLOGY.

BY

E. P. STEBBING, F.L.S., F.Z.S., F.R.G.S., F.E.S.,

Imperial Forest Zoologist.

General.

Investigations carried out during the year in the Sál (*Shorea robusta*) belt of the Central Provinces have resulted in some interesting discoveries with reference to the distribution or absence of the most serious of the insect pests infesting this tree in the three areas it occupies in the country. The three sál belts may be taken as comprising the United Provinces Terai and Oudh Sál belt, the Central Provinces and Chota Nagpur extending down into Ganjam sál belt and the Eastern Bengal and Assam Sál area.

The longicorn pest *Hoplocerambyx spinicornis*, Newm. is common to the Central Provinces and Assam Sál areas but is replaced in the United

Provinces area by the longicorn *Æolesthes holosericea*. This year has resulted in the discovery of a bark-borer pest, a species of *Sphærotrypes*, which differs from the species of this genus present in the United Provinces and again from that present in Assam.

In all three areas the shoots of the tree are subject to the attacks of a shoot-borer (a species of *Arbela*) but the insect is different in all the areas. Coming now to the defoliators whereas *Boarmia selenaria* is the worst defoliating pest in the United Provinces areas followed during the rains by *Ingura subapicalis* Walker, in the Central Provinces the *lasio-campid* *Trabala Vishnu* is the chief defoliator, whilst in Assam and Eastern Bengal several species of *Lymantria* and a *Dasychira* commit the chief damage.

The determination of the pests infesting the seed is still under investigation, but sufficient progress has been made to emphasize the fact that the insects infesting it in the three belts differ from one another.

In the determination of the chief defoliators of the sál in the Central Provinces considerable aid was received from Mr. A. P. Percival, I.F.S., who inaugurated a series of most successful investigations during the year.

The work of combating the bark-boring beetle attack in the Simla Catchment area deodar forests was carried on throughout the year by the Divisional Officer and his Assistants and the measures introduced have resulted in stamping out the attack or reducing it to negligible proportions. By means of the method of felling green trees to serve as 'trap' trees to entice the beetles to oviposit in them the complete life histories of the buprestid beetle *Amorphosoma* sp. and the longicorn beetle *Trinophylum cribratum*, previously entirely unknown, have been completely worked out. This is a most valuable piece of investigation work which reflects great credit on the Punjab Forest officers.

During a tour in Chamba State a serious bark beetle attack in the Bré and neighbouring forests was investigated.

The investigations into the life-history of *Chermes himalayensis* Steb. (*C. abietis-piceæ* Steb.) commenced in 1901 were carried on during the year and have reached an advanced stage. The results arrived at have been incorporated in a Memoir illustrated by coloured plates drawn in the forest.

THE CHIEF ECONOMIC RESULTS OF THE YEAR.

(a) BY THE IMPERIAL FOREST ZOOLOGIST.

The Simla Catchment Area Bark-boring beetle attack.

The measures initiated in May 1908 (alluded to on page 138 of the Report for last year) and continued throughout the year and up to the burst of the monsoon of the present year appear to have proved successful in stamping out or reducing the attack of bark-borer beetles *Scolytus major* Steb. and *Polygraphus major* Steb. which made their appearance in the deodar areas of the Simla Catchment area forests in February 1908. The method employed was to fell a succession of 'trap' trees (*i.e.*, green deodar trees) at intervals throughout the period and to bark these and burn the bark as soon as the grubs, hatched from the eggs laid in them by the beetles, had nearly reached full growth. During these operations it was noted in August 1908 that a number of the trap trees (felled in May) contained young buprestid and longicorn larvæ obviously hatched from eggs laid since the trees were felled. Trees so attacked were kept under observation throughout the period and nymphs and mature beetles were obtained from them in May and June of the present year. The life-histories so worked out were, as mentioned last year, previously unknown, the buprestid proving a species of *Amorphosoma* at present unidentified, whilst the longicorn is *Trinophylum cribratum* not previously reported from the locality or known to live in the deodar.

The Central Provinces Sal Pests.

Hoplocerambyx spinicornis (The Singbhum Sál Borer).—This longicorn is now well known as one of the worst of the insect pests of the sál tree in the Central Provinces and Eastern Bengal and Assam sál areas. It does not occur in the United Provinces sál areas, it being replaced in this locality by the longicorn *Aolesthes holosericea*. *Sphærotrypes* sp. (Sál bark-borer).—A species of *Sphærotrypes* which may prove identical with Blandford's *S. globulus* was discovered abundantly in the bast layer of newly felled sál trees in Mandla in April. The insect attacks the tree in a similar manner to the other two species of the genus, *siwalikensis* Steb. and *assamensis* Steb. of the United Provinces Terai and Assam sál belts respectively.

Trabala Vishnu and Thosea ? sp. (Sál defoliators).—One of the most important defoliating pests of the sál tree in the Central Provinces is the larva of the Lasiocampid moth *Trabala Vishnu*. With the help of the local forest officers the first two generations of the life-history (between January and May) of the year were worked out during the period under report.

Arbela ? sp.—A species of this bark-eating family of caterpillars was discovered killing the young shoots and leaders of sál saplings. It differs in size from the similar pests of the other two belts being intermediate between them.

Other Sál pests.—Observations were carried out on several other defoliators and on some of the seed destroying pests of the tree. These latter pests, the larvæ of minute moths mostly, differ apparently from the insects infesting the seed in Assam and the United Provinces.

Coniferous Pests of the Western Himalayas.

Chermes himalayensis, Steb. (*C. abietis-piceæ* Steb.)—The intricate life-history of this Chermes which passes through alternate generations on the Spruce and Silver fir in this region has occupied the attention of the writer since 1901. Two preliminary papers on some points in the life-history were read before the Asiatic Society of Bengal in 1903.* Observations carried out since that year have resulted in it being possible to compile a Memoir on the life-history of this exceedingly interesting insect.

Bark-boring beetle pests in Chamba State.—During a tour in Chamba State an inspection was carried out of an area of deodar and blue pine forest (the Bré and neighbouring forests) situated at elevations between 7,500 and 9,500 feet. A considerable number of the trees had died during the past two years either singly or in patches and strips running up the precipitous mountain slopes. At the higher elevations where the spruce replaced the deodar this tree had also been killed out in some numbers. The mortality of the trees was of serious importance since they clothed the catchment areas of important streams.

An examination of the trees showed that the death of the trees was almost without exception due to bad bark-boring beetle attacks.

The Deodar trees had been killed by *Scolytus major* Steb. and *Scolytus minor* Steb. and *Polygraphus major* Steb. Traces of the buprestid

* Jour. As. Soc. Bengal, LXXII, Pt. II, 57, 252.

beetle *Amorphosoma* sp. and the longicorn *Trinophylum cribratum* were also present. The blue pine had been killed by *Tomicus Ribbentropi* Steb. and *Polygraphus major*, these two beetles being responsible for the death of the spruce trees at the higher level.

The little coniferous bark beetle pest *Pityogenes coniferæ* Steb. was present, or its galleries were present, in all the trees.

The inspection showed that there could be little doubt that had the cause of the attack been correctly gauged at its commencement and methods to combat it been inaugurated numbers of trees now dead could have been saved.

This attack taken in conjunction with the attack of the same beetles in the Simla Catchment area during 1908-09 forms a striking demonstration of the danger of allowing these bark beetles to get the upper hand in the Himalayan Coniferous forests and of the importance of the forest officers making themselves thoroughly acquainted with the appearance and life-histories of these minute pests. The attack in the Simla Catchment area was taken in time and the measures promptly instituted to combat it have resulted in the beetles being stamped out. There is no reason for supposing that the Chamba attack could not have been treated in a similar manner.

Other Coniferous Pests.—A large number of other bark, wood, defoliating, shoot-eating, and cone and seed-boring pests received attention during the year. The life-histories of a number of the commoner forms have made such progress that they are being incorporated in a Memoir the first parts of which have been submitted for publication.

(b) BY OTHER DEPARTMENTAL OBSERVERS.

Tomicus Ribbentropi, Steb. in Rawalpindi.—A sudden attack of this bark-borer was reported in blue pine in the Rawalpindi Division. About eighty infested trees were cut out, the bark stripped off and burnt and the attack stamped out.

Scolytus major Steb. and Polygraphus major Steb. in Kulu.—The Divisional Forest Officer reported that these two bark-borers were infesting deodar and blue pine respectively in Kulu.

Melolonthid and Elaterid grubs killing deodar seedlings in Jaunsar.—Mr. H. G. Billson reported a serious attack of these grubs in deodar nurseries in the Jaunsar Division. A considerable number of seedlings were killed, the tap roots being cut through by the grubs. Later in the year a third grub, that of a Noctuid moth, made its appear-

ance and proved an even worst pest, the caterpillars ringing the main root just below the surface of the soil and killing numbers of young plants. Remedies were suggested for dealing with the grubs.

Cœlosterna scabrata in *Acacia arabica* at Kalpi.—This pest has been alluded to in previous years as having proved a serious pest in Berar plantations. During the year it appeared at the Kalpi plantations in the United Provinces and destroyed a number of young trees.

***Pinus longifolia* shoot borer.**—The caterpillar of a small Pyralid moth appeared in large numbers throughout the *Pinus longifolia* areas in the Western Himalayas and caused the terminal shoots of the trees to drop off by tunnelling up them and killing them.

Bombay Pests.—The wood-borers *Sinoxylon crassum* and *Sinoxylon anale* were reported as infesting firewood at Sukkur and a wood-boring caterpillar to be tunnelling into *Chloroxylon Swietenia* and *Albizia amara*. The teak branch gall (*Cecidomyia* sp.) was plentiful in Surat.

Mango Pests.—The serious attack of the longicorn grub *Batocera* sp. in the Ganjam plantations continued to be investigated during the year whilst the mango Jassid pests *Idocerus clypealis*, *niveolus* and *Atkinsonii* were reported from mango gardens in the Miani Forests near Hyderabad, Bombay.

Longicorn wood-borers in the Southern Shan States.—Mr. A. W. Watson, I.F.S., has commenced a series of highly interesting and important investigations into the Cerambycid wood-borers in some of the forest trees in the Southern Shan States.

(c) BY OTHER OBSERVERS.

The Bark-boring beetle Attack in Zhob.—A further report on the steps being taken to stamp out the attack of the Chilgoza bark-borers *Polygraphus Trenchi* Steb. and *Phlæosinus Zhobi* Steb. in Zhob was submitted by Captain James, I.A., Assistant Political Agent. The attack has now been practically suppressed.

Pests of the Ziarat Juniper Forests.—Investigations are being carried out into some longicorn and Scolytid pests of this tree in the forests near Ziarat in Baluchistan.

Oak Wood-borers in the Naini Tal Brewery.—A further report on the subject of some longicorn grubs boring into the oak timber used by this brewery was received during the year.

Chief Scientific Results of the year.

Perhaps the most important scientific result of the year is connected with the observations made on the life-history of *Chermes himalayensis* Steb. illustrated by a series of coloured plates of the various stages drawn out in the forest. The life-history shows important points of difference from that of the European *Chermes viridis* Linn — differences which are accentuated by the prevalence in India of a monsoon from July to September.

The discovery of the *Sphærotrypes* in the Central Provinces sál belt and the working out of the complete life-histories of the deodar buprestid beetle *Amorphosoma* sp. and the longicorn *Trinophylum cribratum* are also results of considerable scientific importance.

List of Publications.

1. MAITLAND- The Cultivation of Lac in the Forests of Sind.
KIRWAN, J. D. (Ind. For., xxxiv, 537).
2. STEBBING, E. P., A Further Note on the Chilgoza Bark-boring
& JAMES, CAP. beetles of Zhob. (Ind. For. Rec. I, Pt. III,
TAIN E. H. S. p. 245).
3. STEBBING, E. P. . A Manual of Forest Zoology for India.
4. Ditto . The Terai Sál bark-borer (*Sphærotrypes siwalikensis*). (Leaf. No. 1, For. Zool. ser.)
5. Ditto . The Teak Leaf Defoliator (*Hyblœapuera*). (Leaflet
No. 2, For. Zool. ser.)
6. Ditto . The Teak Leaf Skeletonizer. (*Pyrausta machœralis*). (Leaflet No. 3, For. Zool. ser.)
7. Ditto . On some Undescribed Scolytidæ of Economic
Importance from the Indian Region I. (Ind.
For. Mem., 1, For. Zool. ser.)
8. Ditto . On some Insect Pests of the Himalayan Oaks
(*Quercus dilatata* and *incana*). (Ind. For.
Rec., ii, Pt. i, 1.
9. Ditto . On some Undescribed Scolytidæ of Economic
Importance from the Indian Region II. (Ind.
For. Mem., I, Pt. II, For. Zool. ser.)
10. Ditto . The Deodar Bark-borer (*Scolytus major*). (Leaflet
No. 4, For. Zool. ser.)
11. Ditto . The blue pine *Polygraphus* bark-borer. (Leaflet
No. 5, For. Zool. ser.)

12. STEBBING, E. P. The blue pine *Tomicus* bark-borer. (*Leaflet No. 6, For. Zool. ser.*)
13. AVASIA, D. N. . Lac and Lac Cultivation. (*Forest Pamphlet No. 4, For. Econ. ser, No. 1.*)

VETERINARY SCIENCE.

BY

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The output and issue of the various products prepared at the Imperial Bacteriological Laboratory at Muktesar is shown in the accompanying table.

NAME.	Quantity prepared. Doses of 5 C. C.	Quantity issued. Doses of 5 C. C.	INCREASE.
Anti-rinderpest	5,45,974	6,27,349	63,141
Anti-anthrax	29,786	30,933	13,695
Hæmorrhagic Septicæmia Vaccine.	5,140	3,500	On trial.
Charbon Symptomatique pillules .	1,860	1,310	1,560
Mallein	9,238	9,052	5,485
Tuberculine	306	144	272

Rinderpest.—We have arrived at the limit of our capabilities for the output of anti-rinderpest serum, the most important product at the laboratory, and as we are working at high pressure a break-down may occur at any time. Some investigations have been carried out in the laboratory regarding the period of immunity which could be expected from the serum alone method and also regarding the nature of the immunity conferred by a simultaneous inoculation of serum and virulent blood where no clinical symptoms of rinderpest are produced and to determine the effect of double doses of serum followed by immediate exposure to natural infection. These experiments have been published in Memoir No. 1.

Investigations are also being made in regard to the practicability of using peritoneal washings in the preparation of serum, as this method

has given very good results in the Philippines, producing serum possessing greater power and reducing the cost of preparation by half.

Hæmorrhagic Septicæmia.—Investigations into the nature of this disease, as it occurs in India, have been commenced by Mr. Gaiger at the Punjab Veterinary College and his interesting preliminary report is being published in the *Journal of Tropical Veterinary Science* No. 4, Volume IV.

Investigations into methods of immunization against the disease have been continued at the Muktesar laboratory and have led to the production of a serum which is capable of conferring immunity for a period of six weeks, and of a dead vaccine which gives immunity for a period of two or three months against the inoculated disease. The serum is not likely to be of much use in the field but as the disease is more or less seasonal, an inoculation with the vaccine would be likely to carry animals in villages where the disease is enzootic through the dangerous season, *i.e.*, the rains. If it will do this, it will render considerable service. It is at present being tried in the field. A description of the method is published in *Memoir* No. 1.

Anthrax.—As our knowledge of this disease increases it appears to be dwindling in importance. There is reason to suppose that it is neither so widespread nor important as we have been led to suppose. It does, however, exist in certain tracts. The investigations into the practical value of the known methods of immunization, with experiments to obtain a serum or vaccine suitable to the conditions of the country are still incomplete.

Surra.—A considerable amount of research work has been carried out both in laboratories and in the field regarding this most important disease of horses and camels.

Method of spread.—Mr. Leese was engaged from the 27th April to the 24th September in a Surra area at Mohand in the Siwalik range, on experiments and observations in connection with the rôle of biting flies in the transmission of the disease. He endeavoured to settle, if possible, whether biting flies are chiefly responsible for the spread of Surra under natural conditions, it being now well established that in laboratory experiments *Tabanus* is capable of conveying the trypanosomes from an infected animal to a healthy one if both animals are bitten within a short interval of time. Also to ascertain what kinds of biting flies are to be found in a Surra zone, both in and out of the Surra season; to note their habits as regards biting of domesticated animals; to carry out transmis-

sion experiments with those varieties of flies which the above observations would indicate to be possibly involved in natural transmission, it being known from an investigation of a natural outbreak of Surra in Kathgodam that the disease can continue to spread amongst horses in the absence of *Tabanus*. His experiments prove that *Tabanus*, *Hæmatopota* and *Stomoxys* are all capable of carrying the trypanosome from a diseased to a healthy animal. The *Tabanus* is the most important, the *Hæmatopota* next, and the *Stomoxys* only an occasional danger. This more or less agrees with observations which have been made in other parts of the world with other trypanosomes. It was impossible for Mr. Leese to carry out experiments regarding delayed transmission with *Tabanus* owing to the difficulty which was experienced in keeping the fly alive in captivity. The second Imperial Entomologist who is collaborating with Mr. Leese on the subject, states that he has never kept *Tabanids* alive for more than a week. Further experiments will be made in this direction next surra season.

Much valuable information regarding the incidence and habits of biting flies at Mohand in the Surra zone was collected. The flies, many of which appear to be new species, have been sent to the British Museum to be named and described. Mr. Leese's report has been published in No. 2, Volume IV, of the *Journal of Tropical Veterinary Science*.

Much information regarding Surra and Surra-free zones has been collected. That regarding camels has been published in the second annual report of the Veterinary Officer investigating camel diseases for the year ending 31st March 1909, which also contains many general recommendations which have been made in addition to the special measures already advised against Surra in camels in particular localities.

Curative treatment.—A considerable number of experiments have been conducted during the year by both Mr. Leese and Mr. Gaiger with a view to ascertaining whether any of the drugs which have been found efficacious in horse trypanosomiasis would be of any practical use in the treatment of camel surra. Mr. Leese's experiments are still incomplete and unpublished but they do not promise well. Mr. Gaiger's experiments with atoxyl and orpiment were negative. These experiments are being published.

Captain Holmes has at present 32 horses, ponies and mules under observation, which have been treated by various arsenical derivatives such as atoxyl and commercial orpiment and orpiment alone as well as a combination of atoxyl, sodium arsenite and arsenious acid. He has also used soamin, arsacetin, etc. The results of these various methods

vary, but some are very good indeed, several of the animals having been free from trypanosomiasis for periods varying from 6 to 15 months after the cessation of treatment. None have shown a return of trypanosomes in the blood. Guiger also succeeded in curing two cases by atoxyl and orpiment but his percentage was not good owing to the variation in the commercial orpiment, which appears to owe its action to the free arsenious oxide it contains. The commercial varieties were used in India and it was found to be much more poisonous than the drug used by Thiroux and Teppaz which was apparently precipitated orpiment which Capt. Holmes finds has little effect in Surra. The results achieved, however, are most encouraging and it really seems as though we have at last in view a satisfactory method of treating this fatal disease. When the details are more accurately worked out we shall try treatment in the field where the disease is very prevalent.

Streptotrichosis.—As reported last year, Captain Holmes made an investigation into a form of lymphangitis occurring amongst cattle in Calcutta and locally known as Calcutta sore. He considered that the causal agent was a *Streptothrix*. Colonel Raymond has been working at this disease for the last two years and has issued a report in which he attributes the disease to a bacillus, bringing it into line with a similar disease in cattle reported from Sumatra by Vryburg.

Piroplasma bovis.—The Imperial Bacteriologist has published some notes on the flagellate forms of *Piroplasma bovis*, in his Memoir.

Tetanus.—New methods of preparing an antitoxin or vaccine are being investigated.

Parasites and parasitic diseases.—A considerable amount of work has been done in this subject. A check list of parasites of the domesticated animals has been prepared by Mr. Gaiger who has also drawn attention to the great prevalence of *Linguatula tenioides* and has recorded the occurrence of *Filaria osleri* in that animal.

Mr. Leese has reported the discovery of two new worms in the Camel, i.e. *Hæmonchus longistipes* and *Ostertagia mentulata*.

Evans and Rennie in Burma have published articles on the parasites of the ox and the elephant in Burma. In the latter animal they have recorded *Fasciola jacksoni* and given a description of the disease to which it gives rise. In the latter they found a new genus not described so far. Also the occurrence of *Gastrodiscus secundus*, *Eurytrema cœlomaticum*, *Paramphistomum bathycole*, *P. scolicoœlium*, *P. cotylophorum* and *P.* nearly related to *streptocœlium* has been recorded.

A good collection of type specimens is being made at the Punjab Veterinary College.

Biting-flies and ticks.—Under the orders of the Government of India collections of ticks and biting flies are made in India by this Department and forwarded to the Imperial Agricultural Entomologist at Pusa. I have this year informed this officer of the wants of the Department in regard to these insects and it is understood that he will describe and illustrate the Tabanidae, collect type specimens for all our teaching institutions and publish life histories of the various genera in our journal.

A great number of flies and ticks have already been collected, and it is understood that they have been sent to England to be identified or named and described, but we have so far received no information on the subject. We are unable to prosecute enquiries regarding their connection with disease owing to lack of staff. The connection between *R. sanguineus* and biliary fever in the dog has, however, been described by Christophers and investigations into the rôle played by biting flies in the transmission of Surra have been commenced by Leese.

A List of Publications contributed during 1908-09.

HOLMES, J. D. E. . Veterinary Memoir No. I.

Containing :—

- PART I . Surra Investigation of an Outbreak of Horse Surra with methods of Treatment with Atoxyl, Tartar Emetic, Mercury and other Drugs.
- PART II . Immunization against Charbon Symptomatique by means of a single vaccine.
- PART III . Immunization against Hæmorrhagic Septicæmia of Bovines, by means of serum, sterile vaccine and Toxin.
- PART IV . Rinderpest—Duration of immunity from (1) Serum alone and (2) Simultaneous methods following a single, double, treble, quadruple and quintuple doses.
- PART V. . A peculiar form of Streptotrichosis among cattle.
- PART VI . Flagellate forms of Piroplasma Bovis.
- PART VII . Note on a Giant Polynuclear cell.
- HOLMES, J. D. E. . Treatment of Surra by Atoxyl and Orpiment
(*Four. Tro. Vety. Sci. Vol. III, No. 4, p. 434.*)

- HOLMES, J. D. E. . Immunization against Charbon Symptomatique by means of a Single Vaccine. (*Four. Tro. Vety. Sci. Vol. IV, No. 1, p. 8.*)

A List of Papers published during 1908-09.

- BURTON CLELAND, J. . Streptococcal Granuloma of lung of a Camel. (*Four. Tro. Vety. Sci. IV, No. 2, p. 133.*)
- CUILLE, M. I. . . Acute experimental Ankylostomiasis in the Dog. (*Four. Tro. Vety. Sci., No. 2, p. 169.*)
- DE GRASCA, V., & DI. DONNA, A. Experiments regarding Immunization against Hæmorrhagic Septicæmia (Barbone) of the Buffalo. (*Four. Tro. Vety. Sci., III, No. 3, p. 330.*)
- EVANS, G. H., & RENNIE, T. Notes on some parasites in Burma, II. (*Four. Tro. Vety. Sci., IV, No. 2, p. 134.*)
- GAIGER, S. H. . . Natural Canine Surra. (*Four. Tro. Vety. Sci., III, No. 4, p. 443.*)
- GAIGER, S. H. . . The influence of Atoxyl and other Chemicals on the course of a few cases of Surra. (*Four. Tro. Vety. Sci., III, No. 4, p. 452.*)
- LEESE, A. S. . . Two diseases of young camels. (*Four. Tro. Vety. Sci. IV, No. 1, p. 3.*)
- LEESE, A. S. . . Experiments regarding the natural transmission of surra carried out at Mohand in 1908. (*Four. Tro. Vety. Sci., IV, No. 2, p. 107.*)
- LEESE, A. S. . . Annual Report of the officer investigating Camel disease.
- LEESE, A. S. . . Prophylaxis of surra in the Camel.
- LEESE, A. S. . . A note on surra in camels.
- LOWE, W. CECIL Anthrax. (*Four. Tro. Vety. Sci., IV, No. 1, p. 53.*)
- MITTER, S. N. Observations on some staining peculiarities of Anthrax Bacilli.
- MONTGOMERY, R. EUSTACE. On the Prophylaxis of Trypanosomiasis, with particular reference to the influence of the Camel in India. (*Four. Tro. Vety. Sci., III, No. 3, p. 301.*)
- NEUMANN, L. G. A new Indian Tick, *Ornithodoros lahorensis*. (*Four. Tro. Vety. Sci., III, No. 4, p. 462.*)

- NUTTALL, GEORGE · Piroplasmosis. The Harben Lectures, 1908.
H. F. (*Four. Tro. Vety. Sci.*, IV, No. 2, p. 144).
- PEASE, H. T., & Notes on the Duration and Course of Camel Surra.
H. S. GAIGER. (*Four. Tro. Vety. Sci.*, III, No. 4, p. 427).
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PROGRAMMES OF WORK FOR 1909-10.

PROGRAMMES OF WORK OF THE VARIOUS SCIENTIFIC DEPARTMENTS FOR THE YEAR 1909-10, AS APPROVED BY THE BOARD ON THE 10th MAY 1909.

1.—Imperial Institute, London, and the Department of Economic Products, Calcutta.

(PART 1).—Reporter on Economic Products.

Investigations as follows, which have been declared already in earlier programmes, will be continued, on :—

- (1) the nature and origin of the various kinds of Myrrh, Frankincense, Byssabol, and allied fragrant gums ;
- (2) the use of *Baccaurea sapida* as a dye stuff or dyeing auxiliary ;
- (3) the classification of the races of juar ;
- (4) the classification and uses of Indian Yams (*Dioscorea*) conjointly with the Director, Royal Botanic Gardens, Kew ;
- (5) the species and races of lemon grass in India and their oils ;
- (6) a survey of the physical and chemical constants of Indian oils ;
- (7) the variability of crude lac and on the exact value of mixing resin in manufacture ;
- (8) the botanic races of *Lathyrus sativus*.

Other investigations to be prosecuted, which have not been mentioned in earlier programmes, will be on :—

- (9) the identification of Burmese pulses (conjointly with the Director of Agriculture, Burma) ;
- (10) the value of certain indigenous drugs (through the Indigenous Drugs Committee) ;
- (11) the drug, *Coptis Teeta*—its forms and chemistry ;
- (12) the origin and composition of Sarcocolla gum.

(PART 2).—Imperial Institute.

Programme of Investigations, chiefly chemical, to be continued or to be undertaken for the Government of India at the Imperial Institute during 1909-10.

The following are the more important investigations which it is proposed to undertake at the Imperial Institute :—

Drugs.

The investigation of the characteristic alkaloids present in the roots of the following Indian aconites will be continued :—*Aconitum palmatum*,

A. heterophylloides, *A. soongaricum*, *A. laciniatum*, and the hybrid *A. laciniatum spicatum*.

Specimens of *Datura Stramonium*, *D. fastuosa* and *Hyoscyamus reticulatus* have been received and the amount of "total alkaloids" present in each case has been determined. Some progress has been made with the identification of the alkaloids in each plant, and it is hoped to complete this work shortly.

Work on the constituents of *Strychnos potatorum* and *Thalictrum foliolosum* will be continued.

Turpentines.

A preliminary report on Indian turpentine oil and colophony is in preparation, and work on the constituents of the oil and resin will be continued during the year, using for this purpose the oleo-resins of *Pinus longifolia* and *P. excelsa* already supplied. This work will be extended to the oleo-resins of other Indian pines as soon as samples of these are received from India.

Oils and Oil-Seeds.

A report on *Bassia* seeds has been despatched to India, and two further samples are under investigation. As increased attention is being given in commerce to the fats derived from these seeds, and it seems possible that their use may be extended in various ways, it is proposed to investigate their constituents more thoroughly, and for that purpose further samples of the fats of *Bassia latifolia* and *B. longifolia* have been asked for.

Correspondence is in progress with the Director-General of Commercial Intelligence in India with reference to a suggestion made by him that it might be worth while to investigate the possible utilisation of cotton seed oil as a source of edible fat to be used as a substitute for "ghi." Work on this subject may be undertaken during the year.

The examination of the non-oleaginous constituents of the seeds of *Schleichera trijuga* will be continued.

Fibres and Cotton.

Samples of the following fibres, of which supplies are stated to be available in the "Report and Programme for 1907" have been asked for, and will be examined—*Debregeasia hypoleuca*, *Desmodium tiliaefolium*, *Clematis montana*, *Sterculia urens* and *Maoutia Puya*. A sample of

the fibre of *Agave sisalana* is advised for examination and will be dealt with as soon as it arrives.

It is also suggested that if any samples of cottons of types new to India, or grown in new districts in India are available, specimens should be sent to the Imperial Institute for examination and afterwards for inclusion in the permanent reference collection of cottons now maintained in the Public Exhibition Galleries of the Imperial Institute.

Rubber.

Samples of Ceara, Castilloa and Para Rubbers forwarded by the Agri-Horticultural Society of Madras will be examined.

Volatile Oil.

The oil of *Mentha arvensis*, a supply of which is stated to be available in the "Annual Report and Programme for 1907," will be examined, as it seems worth while to ascertain how the Indian Oil compares with the Japanese Oil of commerce.

2.—Meteorological Department.

METEOROLOGY.

1. *Sounding Balloons*.—The preliminary work of this nature indicated in last year's programme having proved successful, considerable attention will be paid in the present year to its continuation and application to Indian Meteorological problems. It is believed also that India is now in a position to undertake on its own lines a share in the International work with sounding balloons, which has in recent years proved fruitful in results. It is proposed therefore to make the necessary preparations for a series of balloon flights in December next, the month chosen by the International Commission in Europe and America for simultaneous experiments on the conditions of the upper air.

2. *Kites*.—It is possible that in addition to the work with balloons some opportunity may occur for resuming the use of kites, which with their more open scale registering instruments, are particularly useful for work on the lowest two miles of the atmosphere.

3. *Atmospheric electricity*.—Continued observations will be made of the chief factors of atmospheric electricity, *viz.*, the potential gradient, ionization conductivity and radio-activity of the air, and of the quantity of electricity carried down by rain and snow.

Experiments are being made with the object of determining the origin of the permanent negative charge on the earth's surface.

4. **Winds.**—It is proposed to continue the publication of the series of memoirs on the winds of India upon which Sir John Eliot was engaged at the time of his death.

5. **Seasonal variations.**—It has not yet been found possible to make a systematic study of the data collected from the logs of ships in the Indian Ocean with a view to finding relations between abnormal conditions there and abnormal seasons. It is hoped that progress may be made this year.

Astronomy.

6. **Variations in the quantity of radiation emitted by the sun.**—An attempt will be made to develop a method of finding the ratio of the brightness of the full moon to that of certain stars under conditions which will eliminate the effect of changes in the atmospheric absorption. Variations in this ratio may be taken as indicating changes in the solar constant.

7. **Photographing the sun in monochromatic light.**—The routine work with the spectroheliograph will be continued, and on the arrival of a new grating it is hoped that photographs will be made with the second slit set for the line H.

8. **Spectra of sunspots.**—Co-operation with the International Solar Union will be maintained. A study is also proposed of :—

- (a) movements in the line of sight ;
- (b) pressure shifts ;
- (c) comparison with limb spectra.

It is further proposed to examine :—

9. **Rotation velocities** near the sun's equator as derived from measures of the H and K lines at the limbs.

10. **Rotation velocities of quiet prominences** as measured in H and K.

11. **The shift to the red** of lines at the limb, determined in different parts of the spectrum and by comparison with telluric lines.

12. **Pressure shifts** at the limb and centre of the disc as obtained by measurements of the relative displacements of lines subject to large and small pressure shifts.

Terrestrial Magnetism.

13. The routine measurements of absolute and variation instruments at Alibag will be continued. It is hoped that the publication of the sixty years' records at Colaba will be completed during the current year.

Seismography.

14. Three Omori seismographs are now registering continuously, two at Simla in the directions north-south and east-west, and one at Bombay. The Milne seismographs at Calcutta, Kodaikanal and Bombay will remain in use during the year.

3.—Survey of India (Scientific Research work).

Gravimetric Survey.—Pendulum operations across the Aravalli and Vindhya hills.

Magnetic Survey.—Colaba Observatory under the Director-General of Observatories, and the four observatories under the Surveyor-General will continue to work. Observations will be taken at 24 Repeat Stations, and detailed surveys of disturbed areas will be commenced.

Solar Photographs.—Photographs of the sun will be taken daily at 10 A.M. and 4 P.M., at Dehra Dun, as has been done since 1879 in conjunction with Greenwich.

4.—Geological Survey.

PART A.—*Subjects undertaken during previous years to be continued.*

- (1) Survey of the Tertiary oil-bearing area in Upper Burma.
- (2) Extension of geological map over previously unsurveyed areas in Central India and the neighbouring States of Rajputana.
- (3) Chemical work on brines from Rajputana and salt samples from the Salt Range, Punjab.
- (4) Revision of the geological map of the Raniganj coalfield in conjunction with a committee appointed by the Mining and Geological Institute of India.
- (5) Mapping of unsurveyed areas in the Central Provinces.
- (6) Palæontology of (a) Liassic beds of Baluchistan, (b) Lower Tertiary marine beds of Baluchistan, (c) Ordovician, Silurian and Devonian rocks of Spiti, (d) Cretaceous and Tertiary Systems of Tibet.

PART B.—*New Questions.*

- (7) Survey of the Dhalbhum Estate, Singhbhum.
- (8) Survey of the Idar State [continuation of (2)].
- (9) Survey of the Karana Hills in the Chaj Doab, Punjab.
- (10) Examination of the fossils from Kangra, Jammu and the Island of Perim off Kathiawar.
- (11) Survey of the coalfields and oil-bearing regions of North-East Assam.
- (12) Palæontology of (a) Carboniferous rocks of the Shan States, (b) Jurassic Brachiopods from the Northern Shan States, (c) Siwalik Vertebrates, (d) Indian Tertiary Mollusca.

5.—**Botanical Survey.**

I.—Country under the Superintendent of the Royal Botanic Garden, Calcutta :—

- (a) **Bengal.**—The chief work during the year will be the making of an accurate census of the non-herbaceous plants cultivated in the Royal Botanic Garden, Calcutta, preparations for which have been completed during the past year. In addition to this the Curator of the Herbarium will be deputed—for as long as he can be spared—to study *in the field* the Flora of the Eastern Himalaya with a view to writing up materials for a Flora of that region.
- (b) **Assam and Burma.**—An endeavour will be made to write up the Flora of the district of Cachar in Assam and to work up material for the Flora of Tenasserim in Burma.

It is unlikely that it will be possible to carry out this programme in its entirety, and considering the very limited staff available it will probably be found more profitable for work to be concentrated upon one thing at a time rather than distributed over several things simultaneously. It is, however, impossible at this stage to state definitely which of the particular subjects after the first one mentioned will be investigated.

II. Survey of Bombay Presidency.—No programme has been submitted.

III.—Survey of Southern India.—Government Botanist, Madras, states that he will be unable personally to do any systematic touring. Tours, however, will be made by his assistants during April and May in the Nilgiris, during July and August in the Nallamalis, and during December

to March in the Travancore hills. This programme has received the approval of the Board of Revenue, Madras.

IV.—Survey of Northern India.—No programme has been submitted.

6.—Agricultural Department.

The scientific work of the Institute for the coming year is indicated under the programmes of the different sections.

The College has been opened, and students are now being admitted. Although it is the intention that only distinguished students from the Provincial Agricultural Colleges should be sent to Pusa for a two years' course in specialising, students are also being admitted for lower courses until the Provinces are able to undertake this work themselves.

A provisional prospectus sanctioned by the Government of India has been communicated to the Provincial Governments, and their replies are awaited.

I.—AGRICULTURAL CHEMISTRY.

1. *Soils*.—The work on the availability of plant food in soils, and the nature of the dark colour of black cotton soil will be continued.

2. *Soil moisture and water requirements of plants*.—The investigations into (a) the destiny of rain water, including as it does, records of drainage through soils, losses by evaporation, and surface flow; and (b) the water requirements of crops, will be continued.

3. *The effect of soil or manure on the composition of certain seeds* is an investigation which has been in progress tentatively and will be extended if considered desirable.

4. *The prevention of weevil attacks on wheat* is an investigation which is being conducted in collaboration with the Imperial Entomologist.

5. *Training*.—Instruction will be given to students on the lines indicated in the Pusa syllabus.

II.—ECONOMIC BOTANY.

1. *Training*.—The teaching work of the section will be continued on the lines laid down in the prospectus of the Institute.

2. *Plant breeding and plant improvement*.—During 1909, the following crops will be studied:—Wheat, tobacco, barley, oil-seeds and fibre plants.

(a) *Wheat*.—The botanical and agricultural survey of the wheats of Bengal will be completed on the lines adopted in the investi-

gations on the Punjab wheats. The production of improved varieties by selection and hybridisation will be continued as well as the investigation of the factors influencing the quality of the grain.

(b) *Tobacco*.—The botanical survey of the Indian tobaccos will be completed.

(c) *Oil-seeds*.—The study of the oil-seeds of India which has been carried on on a small scale during the past year will be extended on lines similar to those adopted in the investigations on wheat.

(d) *Barley*.—The work on this crop will be continued.

(e) *Fibres*.—The collection and investigation of fibre-yielding plants will be continued.

3. *Fruit experiments*.—The permanent experiments on the culture of Indian fruits will be continued on the lines laid down in the first report.

4. *Minor investigations*.—The economic importance of the male plant in ganja cultivation and the problem of the inheritance of sex. The study of cassava as a famine food (with Dr. Leather).

III.—MYCOLOGY.

1. *Training*.—The training of students in Mycology will be continued. Those at present under training are probationers for posts of Mycological Assistants in Provincial Departments of Agriculture. Assistance will be given to Provincial Colleges in providing notes and material for Mycological instruction.

2. *Plant disease investigations*.—Work on sugarcane diseases will be continued. A further paper on red-rot will be published. The study of a new sugarcane disease has been commenced. The supernumerary Mycologist is investigating the life history of sugarcane smut.

Assistance will continue to be given in the operations to check bud-rot disease of palms in Godaveri.

The work on pigeon-pea wilt will be published. That on the wilt of indigo is being continued. Arrangements will be made, if possible, for a local study of cotton wilt. Gram and other wilts will be further studied if opportunity arises.

The chief diseases of mulberry and fruit trees in Kashmir will be reported on.

The supernumerary Mycologist is engaged in an investigation of a ginger disease prevalent in Bengal and Bombay.

The study of some anthracnoses of leguminous crops will be taken up.

3. *General*.—The survey of Indian parasitic fungi will be continued. It is hoped to complete the text of the book on Indian plant diseases.

IV.—ENTOMOLOGY.

1. *Research and experimental work*.—The work of the past year in studying and advising on crop pests will be continued. Assistance will be given, where desired, in directing the work of Provincial assistants and in coping with any outbreaks of pests that may occur. The issue of coloured plates of injurious and beneficial insects will be continued. Inquiries in progress on insecticides, on potato moth, on fumigating plant-imports, on the treatment of grain by fumigation will be continued as time permits. Further work on lac cultivation will be done, both in Bihar and other parts of India, in the cultivated areas; the cultivation of *eri* silk will be continued on a small scale at Pusa, and assistance will be given to those carrying on the cultivation in new localities; the work in progress on spinning, weaving and dyeing will be continued. The cultivation of mulberry and *tassar* silk on a very small scale as a demonstration to students will be begun.

2. *Training*.—The teaching of advanced Entomology, commenced in August 1908, will be continued and must form a large part of the work of the section. The publication of the "Manual of Indian Entomology" should be completed by July, and it is proposed to publish revisions in vernacular of "Indian Insect Pests." All necessary assistance will be rendered in carrying out the course of training for students at Pusa during the year.

3. *Investigation*.—More members of the Veterinary Department will, it is hoped, be sent for short courses on the methods of observing insects parasitic on, or otherwise harmful to, cattle, horses and other stock; work on these insects, on blood-sucking Diptera and on Dipterous crop pests, will be continued.

4. *Publication work*.—The work of the artists' staff of the Journal and Institute, at present under my control, will continue to be directed and supervised as hitherto.

V.—AGRICULTURAL BACTERIOLOGY.

Some of the following problems will be attacked as opportunity offers and time permits :—

I.—The chief bacteria characteristic of Indian soils particularly those taking part in—

- (a) The fixation of nitrogen.
- (b) The rotting of organic material.
- (c) Nitrification.

II.—The characteristic organisms growing in association with leguminous crops in India, with particular regard to the inoculation of the soils growing them.

III.—The bacteria taking part in the rotting of stored organic material under Indian conditions and the bearing of the knowledge gained on the conservation of cattle-manure in India.

IV.—The fermentation processes accompanying the manufacture of silage in India.

V.—The fermentation processes taking place during the manufacture of tobacco.

VI.—The fermentation processes taking place during the manufacture of indigo.

VII.—Any bacterial diseases of important Indian crops.

VI.—AGRICULTURE.

1. *Permanent experiments.*—The permanent manurial and rotation experiments and the permanent pasture experiments will be continued.

2. *Flax and other fibres.*—Experimental work on a field scale on these crops will be continued.

3. *Sugarcane.*—Work on sugarcane as described in last year's programme will be continued.

4. *Tobacco.*—Experimental work on curing in the curing house will be taken up, provided an expert can be obtained.

5. *Varieties.*—Wheat, barley, maize, rice and castor varieties will be tested.

6. *Threshing trials.*—Wheat threshing trials will be continued under the direct charge of a threshing expert who will be sent out by an English firm.

7. *Breeding*.—Breeding work will be considerably extended. The Montgomery herd now numbers over forty cows and will be further increased. Milk records are kept for each cow, and by breeding from the best cows it is hoped that the milking powers of the herd will be substantially increased. The local herd of the cows will probably be transferred to the Bengal Agricultural Department. Ewes from Bikanir and from Gorakhpur district will be crossed with Dumba rams on a fairly large scale. Seven new breeds of fowls have been received from England. There are now nineteen breeding pens in addition to ducks, geese and turkeys.

8. The general improvement of the estate will be continued. One hundred and fifty acres will be added to the present arable area.

9. *Training* of students from the Provinces will be continued.

The Programme of the Imperial Cotton Specialist.

To visit and advise in any Province when he is requested to do so.

2. To make special investigations into the distribution of Indian cottons in the field throughout the country, more especially for the purpose of ascertaining exactly where the most valuable forms of each variety are grown and to discover, if possible, the natural causes which favour these.

3. To arrange for trial with superior varieties already discovered, such as (1) with *Karkheli* cotton in the Central Provinces, Kathiawar, Berar, Khandesh and the Deccan, where inferior varieties of the same type are already grown; (2) with Navasari cotton (the most valuable form of Broach) in Gujarat, Southern Maratha country and the northern parts of Madras; (3) with *Bourbon* cotton in the heavier rainfall tracts of the West Coast.

Provincial Departments of Agriculture.

The programmes for 1909-10 generally follow those described in 1908-09. The following are, however, important additions:—

Bengal.—The College Farm at Sabour will be laid out for general comparative work and special investigations. The principal crops selected for experiments in this Province are paddy, jute and sugarcane. At Kalimpong it is proposed to collect information on the crops and the agricultural practices of the Darjeeling Hills. Well-boring experiments will be undertaken this year in Bihar. The classification of the different types of sugarcane will be begun to determine (a) the dates of ripening

in the different varieties, and (b) the glucose content and their chemical characters. The nitrifying power of different typical soils of Bengal will be studied.

United Provinces.—Two more experimental stations—one at Atarra and the other at Benares—will be opened during the year. The former is situated in the Bundelkhand and is designed to pioneer agricultural improvements rendered possible by the introduction of irrigation. A horticultural station has been established in the Kumaon Hills for the development of fruit and vegetable growing. The Rampore State is taking up the supply of high grade poultry for breeding. At Cawnpore the outturns of certain pure strains of wheat are being compared with reference to their milling qualities. The amount of loss at different stages of Mr. Hadi's process of sugar manufacturing will be determined by the Agricultural Chemist to ascertain whether any further improvement is possible. The reclamation of a portion of bad land (locally known as "Rakar") by enclosing and heavy manuring with poudrette is being attempted. Experiments with soil moisture which are in progress at Cawnpore have been extended to investigate (a) losses of soil moisture by cropped land under different crops with and without manures, and (b) losses of soil moisture from land irrigated with an accurately measured quantity of water, (i) bare fallow, (ii) grass and weeds, (iii) wheat.

Punjab.—It is proposed to open an agricultural station at Jullunder for the study of sugarcane, of well problems and other questions connected with that important agricultural tract. The question of sub-soil ploughing in case of worn-out soils will also be taken up at this station. At Lyalpur tests will be instituted to ascertain the amount of water required by wheat and cotton under irrigation. Depôts for agricultural machinery will be started. An area of ground will be set down to grow local and foreign fruit trees of economic value. Experimental cultivation of Cassava will be tried to determine whether it can be introduced as a cheap food crop. Experiments will be made to ascertain whether flax and jute can be profitably introduced as farm crops of the Province. A well-survey of certain districts will be made with a view to extend well-irrigation where possible. The Department will undertake to make experiments at typical places for the revival of sericulture.

Bombay.—Several foreign and indigenous varieties of wheat are being tried at a number of the stations. Individual selection is being made to increase (a) rust-resistant qualities, (b) yield, and (c) quality.

The Department will test in the Ahmedabad district the relative advantage of Broach cotton over the local variety. Efforts will be made to push the cultivation of Broach cotton in the Southern Maratha country where it is found to grow successfully. The operations of cane growing, crushing, boiling and *Gul* manufacture are under study at Manjri. The factors which determine the value and keeping qualities of *Gul* are being investigated. The Hadi process of sugar manufacture will be compared with the native process of *Gul* manufacture under Poona conditions as regards profits. On the Nadiad farm the growth of foreign tobaccos under shade is being investigated. It is proposed to establish a seed-testing station in connection with the Poona Agricultural College. Experiments in dry farming have been begun at Rahuri in Ahmednagar district. Well-boring experiments have been started in Gujarat. In the Deccan large sized oil-engines will be tried for economy in pumping water from rivers and crushing sugarcane grown under irrigation. A workshop is to be attached to the College for the improvement and experimental manufacture of iron ploughs, chain pumps, chaff-cutters and other agricultural implements.

Madras.—The District Board Farm at Bezwada has been taken over by Government. Preliminary investigations into the paddy cultivation of Kistna and Cavari deltas have been set on foot. The amount of water required to raise a full crop of paddy will be tested at Coimbatore and Samalkota. Experiments will be made in the use as manure of fish scrap for paddy, especially on the West Coast where it is available. The introduced Mauritius sugarcanes having ousted the local canes in the Godavari delta, it is proposed to test the suitability of other new varieties. A Hadi boiling plant will be erected at Coimbatore and Samalkota for the improvement of the local manufacture of jaggery. The use of the drill for sowing cotton as a pure crop in the Trichinopoly district will be extended. The cultivation of groundnut as a rain-fed crop will be introduced into the Malabar Coast districts. Natural pasture grasses are being studied under cultivation at Taliparamba where fodder for cattle in dry weather is a great want. Cassava and ginger largely grown on the dry lands of Malabar will be taken up for study.

Central Provinces.—Manurial and varietal experiments will be started with sugarcane on the Raipur Farm, as this crop is likely to become important in Chattisgarh with the extension of flow irrigation. Interesting experiments are in progress on the Akola Farm to test the value of gram and certain other legumes as soil renovators when grown in alter-

nate lines with cotton. The effects of different forms of tillage and cultivation in relation to water content and movement on black cotton soil will be examined.

Burma.—Manurial experiments with paddy are proposed to be undertaken at Mandalay. Special efforts are to be made to popularise bone-meal. The indigenous varieties of wheat will be classified, and some introduced varieties are to be grown. Selection and crossing of indigenous varieties of cotton are to be attempted. A scheme for the utilization for agricultural purposes of the sewage and nightsoil of towns is under preparation in consultation with the Sanitary Commissioner. Fruit experiments will be started at Katha, Hmawabi and Mandalay. Experiments are in progress to ascertain (1) the relative yield of various varieties of groundnut, (2) the percentage of oil, and (3) the power of resistance to disease. The correct time of planting Egyptian cotton in Burma will be ascertained.

Eastern Bengal and Assam.—At Rajshahi and Jorhat sugarcane experiments will be started with a view to find out the cane most suitable under the manurial treatment in vogue in those districts. Jute refuse is being tried for its value as organic manure. It is proposed to take up a general investigation of the varieties of rice with a view to selection and breeding experiments. The Sumatra and the local *Bhengi* varieties of tobacco will be grown, each on an acre for special experiments in regard to after-treatment. The object is to produce tobacco suitable respectively for cigars and cigarettes. The work in sericulture will be directed towards (1) making available an adequate supply of seed cocoons guaranteed as practically free from disease, and (2) giving a sound practical training to the sons of silkworm rearers. Investigations into the possibility of introducing simple machines with the object of (a) lessening the large amount of labour, and (b) reducing the large volume of water required at present for the retting of jute and similar fibres will be undertaken by the fibre expert. The sources of material for paper making are being studied by Mr. Finlow as opportunities arise.

7.—Forest Department.

The following are some of the various investigations which will be made by officers of the Imperial Forest Research Institute, Dehra Dun, with the assistance of other officers of the Department.

I.—WORKING-PLANS.

1. The compilation from selected Working-Plans of data regarding the rate of growth of different species (ring countings, sample plots) and generally the tabulating, in convenient form, of statistics and information regarding different species, methods of working, etc., now scattered throughout the plans. A statement showing sanctioned Working-Plans, with area of forest, period of plan, method of treatment and principal species has already been compiled as a basis of this and other investigations.

2. With regard to normal stock, selected areas containing what appears to be a full stock of I, II, III and other classes will be counted out, and the average of each class taken as an approximate normal, as a preliminary to the more accurate investigation of this subject. The following species will be first taken in hand—Sâl, Teak, Deodar, *Pinus longifolia*, *Pinus excelsa*, and other species now being worked under Working-Plans as soon as possible.

3. A careful study of the selection system will be made. The following points merit attention in this regard in order to discover the best means of working by compartments so as most nearly to approach the ideal method of working over the entire area annually for the removal of mature trees, *e.g.*—

- (i) By making the annual coupes as large as possible so that the area may be worked over at as frequent intervals as possible.
- (ii) By fixing such an exploitable girth that the loss of interest due to leaving mature trees standing for an excessive period is reduced.
- (iii) By allotting gradually decreasing areas for the annual coupes.

4. The examination of control forms in order to ascertain the average outturn by different methods of working in force, and generally to collect and collate the statistics of the results of forest management throughout India which are included in past control forms will be continued.

5. Preparation for teak of a paper setting forth all that is known regarding habits, methods of treatment, etc., such as has already been prepared for the sâl.

6. Preparation of yield tables (as far as data are available):—

- (i) Sissoo Plantations at Changa-Manga.
- (ii) Eucalyptus plantation at Ootacamund.
- (iii) Casuarina plantations in Madras.
- (iv) Teak plantations at Nilambur.

7. Preparation of tables of outturn :—

- (i) Some selected high forests in the United Provinces (or elsewhere) under the selection system, in which enumerations have been carried out.
- (ii) Some selected sâl coppice forest in the United Provinces.
- (iii) Teak forest in Burma.

8. Preparation of a note on the application of the *uniform method* with special reference to India and with examples from Indian working plans.

9. Upkeep of Registers of sample plots and publication of any data available.

10. Opening of ledger files relating to definite subjects under investigation or to be hereafter brought under investigation.

II.—SYLVICULTURE.

11. Study of the effects of fire conservancy on different species in various conditions of climate and growth, more especially on sâl and teak, will be continued.

12. An examination into the conditions favourable to the replacement of the selection method by the regular method will be continued.

13. Investigation into the effects of soil composition and underlying rock on the distribution and growth of different species will be continued.

14. Enquiry into the effects of the continuance of a given species (*e.g.*, sâl, teak) as regards the soil fertility for that species will be continued.

15. Collection of information regarding plantation work carried out on a large scale, specially Agri-Sylvicultural operations and the planting of arid lands and shifting sands; and the publication of pamphlets dealing with these subjects.

16. The study of teak reproduction in conjunction with the Imperial Forest Botanist and the Imperial Forest Chemist.

17. The study of sâl reproduction in conjunction with the Imperial Forest Botanist and the Imperial Forest Chemist.

18. Putting in order the Kaunli garden for sylvicultural research purposes in conjunction with the Imperial Forest Botanist.

19. Subjects to be investigated on the initiation of Conservators by them in conjunction and in correspondence with the Sylvicultural branch of the Research Institute.

III.—FOREST ZOOLOGY.

20. Investigation (in the United Provinces) into the distribution and life histories of the *Monophlebus* scale insect, *Spærotrypes siwalikensis*, and the sâl defoliators in the sub-montane sâl areas of the Ganges, Garhwal, Kumaun and Naini Tal divisions and into the *Pinus longifolia* *Cryptorrhynchid* weevil, *Tomicus* and *Polygraphus* bark-borers and *Platypus* wood borer in the *chir* areas of Garhwal, Kumaun and Naini Tal divisions will be continued.

21. Investigation (in the Punjab) into the distribution and life histories of the following insects in the hill coniferous forest of the Kangra division :—

The *Scolytus* pests of the deodar and the *Polygraphus*, *Pityepenes*, *Platypodæ* and cone-borers and defoliators of the *Pinus excelsa*, Spruce and Silver fir: also the defoliating and wood-boring pests of the hill oaks and pests of *Pinus longifolia* will be continued.

22. Investigation into the autumn generations of the life histories of the insect pests of Deodar, Silver fir, Spruce, Blue Pine, and *Pinus longifolia* will be continued.

23. Investigation into the insect pests of the sâl tree in Oudh.

24. Investigation into the life history of the *Padauk* weevil pest and the *Padauk Scolytid* wood-borer.

25. Investigation into an important *Scolytid* wood-borer of the "sundri," a defoliating pest of this tree and other pests of the mangrove forests.

26. Boring molluscs of bamboos in tidal waters in Burma.

27. Destruction of babul plantations in Berar by rats and a longicorn beetle.

28. Predaceous and parasitic pests of the lac insect.

IV.—FOREST ECONOMY.

29. The enquiry into the utilization of the less valuable kinds of timber as railway sleepers will be continued, and a practical experiment is being made with sleepers obtained from *Dipterocarpus* sp. from Burma and the Andamans.

30. Enquiry will continue into the subject of :—

(a) Woods suitable for the manufacture of matches.

(b) Cultivation of lac.

- (c) Antiseptic treatment of timber, particularly for railway sleepers.
- (d) Utilization of various oil seeds from forest trees.
- (e) Utilization of *Xylia dolabriformis* waste for paving blocks.
- (f) Woods likely to be useful for minor industries.
- (g) Woods for tea boxes.
- (h) Camphor (Lævo-Borneol) from *Blumea balsamifera*.
- (i) Cultivation of *Podophyllum Emodi*.
- (j) Cutch.
- (k) Destructive distillation of wood in conjunction with the Imperial Forest Chemist.

31. Investigations will be made into the following subjects:—

- (a) Actual process and prospects of the manufacture of matches as a commercial enterprise; best sites for the establishment of match factories and available supply of timber suitable for the manufacture of matches.
- (b) Wood-pulp industry.
- (c) Wood suitable for the manufacture of casks, packing cases and opium chests.
- (d) Powellizing inferior woods.
- (e) Padauk wood from the Andamans. Cause of falling off in demand, and possible measures for stimulating it.
- (f) Investigation into the physical properties and seasoning powers of various woods.
- (g) Utilization of gum resins.

V.—FOREST BOTANY.

32. Enquiry into the following subjects will continue:—

- (a) Study of the coppicing of teak, its effect on the normal health and development of the tree.
- (b) The grasses of the Savannah tracts will be examined with special reference to their difference in burnt and unburnt areas.
- (c) A practical examination will be continued into the effects of fire on grazing areas in order to ascertain:—
 - (i) Whether the grass on areas burned over annually decreases in quantity and quality:

- (ii) whether this result or the reverse happens in the case of areas protected from fire, and especially whether protection from fire encourages the growth of coarser grasses or leads to the replacement of coarse grasses by others more suitable for fodder.
 - (d) A study will be made of the timber of different species of *tun* and *Grewia* to ascertain which yield the most valuable wood.
 - (e) Investigation (in the Madras Presidency) into the subject of the rising of marks on tree stems, used to indicate fixed levels of measurement in sample trees or plots.
33. The following subjects will receive attention :—
- (a) Study of Teak reproduction.
 - (b) Study of Sâl reproduction.
 - (c) Rearrangement and putting in order of Saharanpur Herbarium (located at Dehra Dun).
 - (d) Putting in order the Kaunli garden for research purposes in conjunction with the Sylviculturist.

VI.—FOREST CHEMISTRY.

34. Further examination of tannin extracts will be made, specially the tannin extracted from mangrove at the Rangoon works with a view to its decolourization.

35. The collection and analysis of the latices of rubber-producing species will be continued.

36. The following subjects will continue to be worked at :—

- (a) The estimation of the amount of oil from seeds of forest trees, and the utilization of the cake.
- (b) Experiments with the newly designed camphor-still and the distillation of camphor (Lævo-Borneol) from *Blumea balsamifera* of Burma.
- (c) Investigation (in Burma) into the various species of *Compositæ* as to their suitability for the production of camphor or any other valuable essential oil.
- (d) Investigation into Catechu with a view to prepare Catechin-free Cutch on a commercial scale will be continued.
- (e) Investigation into the manurial value of the various leaves, twigs and shrubs indigenous in the Madras Presidency, in

order to ascertain the proportion of nitrogen and phosphoric acid, etc., which they contain.

37. Enquiry will be made into the following subjects :—

- (a) Investigation into the destructive distillation of wood in conjunction with the Imperial Forest Economist.
- (b) The improvement of the processes of distillation of *Rhusa* grass oils.
- (c) Calorific power of different Indian timbers.

VII.—GENERAL.

38. Pamphlets, circulars, as well as the Memoirs and Records of the Forest Department setting forth the results of investigations into various subjects affecting the progress of Indian Forestry, will be published from time to time.

8.—Natural History Section, Indian Museum.

In view of the fact that certain changes in the staff have recently been sanctioned, it is possible to submit a purely provisional programme only.

The Superintendent will continue his work on the invertebrate fauna of stagnant water in India and, in collaboration with the Assistant Superintendent, will commence a revision of certain families of fresh water fish.

The Surgeon Naturalist, Indian Marine Survey, will conduct investigations in the Museum on the degenerate males of cirripedes.

The Scientific Adviser on Fisheries to the Government of Bengal in conjunction with the officers of the Museum, will study the fishes taken by the fishery steamer.

Mr. E. Brunetti will continue his work on Indian Diptera devoting special attention to the *Tipulidæ*, *Empidæ* and *Phoridæ*.

Captain R. E. Lloyd, I.M.S., will complete his survey of the races of Indian rats.

9.—Civil Veterinary Department.

By the Imperial Bacteriologist—

- (1) **Anthrax.**—To continue the investigations laid in the programme of the previous year.

- (2) **Charbon Symptomatique.**—The preparation of an Antiserum.
- (3) **Surra.**—Methods of treatment.
- (4) Further tests of vaccines prepared during the past year against Hæmorrhagic septicæmia and Charbon symptomatique.

By the Officer investigating Camel diseases—

- (1) Investigations into surra in the field.
- (2) The study of Filariasis in the Camel.
- (3) Treatment of surra in the Camel.

By the Provincial Staff—Punjab Veterinary College Laboratory—

- (1) Treatment of surra.
- (2) Study of Hæmorrhagic septicæmia.

Provincial Superintendents—

Collection of information and the mapping out, as opportunity occurs, of the incidence of Surra, Piroplasmosis, Hæmorrhagic septicæmia and Anthrax.

APPENDIX.

APPENDIX.

ECONOMIC INVESTIGATIONS CONDUCTED FOR THE GOVERNMENT OF INDIA AT THE IMPERIAL INSTITUTE DURING THE YEAR ENDING 30th SEPTEMBER 1909.

BY

W. R. DUNSTAN, M.A., LL.D., F.R.S.,

Director of the Imperial Institute.

The scientific investigations which have been in progress at the Imperial Institute for the Government of India are :—

1. An examination of a number of Solanaceous plants, species of *Hyoscyamus* and *Datura*, involving the separation and identification of their principal constituents. This work has been completed and generally reported on, with the exception of one species of *Datura* which is still under investigation.

2. The examination of the constituents of several species of Indian aconites. This work has made considerable progress, but is not yet completed.

3. The examination of the constituents of the chief varieties of Indian opium collected in the various opium districts of India in continuation of a previous enquiry. This work is in progress.

4. An examination of the constituents of Indian turpentine from *Pinus longifolia*, *P. excelsa* and *P. Gerardiana*. A first report on this work has been made.

In addition to these scientific investigations which have been conducted at the Imperial Institute, several similar enquiries have been undertaken in co-operation with the Imperial Institute by well-known authorities on special subjects. Certain of these will be completed at an early date.

A large number of Indian economic products received from the Reporter on Economic Products and other Indian officials have been technically examined and commercially valued, and in some instances also submitted to manufacturing trials. These include fibres, oil seeds, volatile oils, tobaccos, cereals and various minerals. Information has been supplied to various Indian merchants and firms respecting the commercial value of many Indian materials, and information respecting Indian materials has been also furnished to commercial firms in this country.

INDEX.

	Page.
A	
Acacia gums	17
Aconites, alkaloids of	229
Adulteration in ghi	19
<i>Æolesthes holosericea</i> , a Sâl pest	190
Agave fibre, chemistry of	23
Agricultural Department Programmes for 1907-10	211
Akarsani Hill, Singbhum, granophyres of	61
Alcohol, chemical work on	26
Alibag, magnetic observatory at	54
<i>Alpinia Allughas</i> , cellulose of	23
Altyn Tagh Range, survey of the	113
Alum, manufacture of	75
Ammonites of Bagh beds	65
<i>Amorphosoma</i> sp., life history of	190
Andaman Padauk	166
Angström pyrheliometers	47
Anthrax, investigations and experiments still incomplete	196
Anti-rinderpest serum alone method, investigations regarding immunity of	195
" " " preparation	195
Antiseptic treatment of woods	170
<i>Arachis hypogæa</i> , oil of	18
Aravalli series of rocks	104
<i>Arbela</i> sp., a forest insect pest	191
Archæan rocks in Chanda	109
Areca nut, fats of	26
Arkose in Tavoy	101
Assam, botanical collections from	132
Atmosphere, electrical conditions of the	50
" " " investigation of the upper	47
" <i>Avenarius Carbolineum</i> " as a wood preservative	170
B	
Bacteria, in connection with toxic substances in soil	14
" " " in heart-damage of jute-bales	22
Bagh beds, Palæontology of	65

	Page.
Balloons, for meteorological purposes	49
Baluchistan, flora of	137
" , Geological Survey in	101
" , irrigation waters in	16
" , Liassic and Neocomian fossils of	69
Bamboo pulp, manufacture of	170
Barnacles, Indian work on	175
Barrackpore, Magnetic Observatory at	54
<i>Batocera</i> , sp., mango pest, —investigation on	193
<i>Bauxite</i> , examinations of	11
Beetles, bark-boring	191
Beldongri (Central Provinces) <i>Vredenburgite</i> at	60
<i>Belemnites</i> (<i>Duvalia dilatata</i>), —examination of	72
Bhandara, manganese in	86
Birds, food of	186
Biting flies and ticks	199
Blood-sucking Diptera	187
Blue Pine, bark-borers infesting	192
<i>Blumea balsamifera</i> , Ngai-Camphor of	28, 37
<i>Boarmia Selenaria</i> , defoliating pest	189
<i>Bombax malabaricum</i> , oil of	18
Bombay, ferns of the Presidency of	135
" , flora of the Presidency of	133
" , Magnetic Observatory at	54
" , Orchids of the Presidency of	135
Boring at Matigara	80
Botanical publications	141
" Survey Programme for 1909-10	210
Bugti Hills, Geological Survey of	101
Buprestid beetle, life history of	190
Burma, botanical collections from	132
" , Upper Tertiary rocks of	72
Burning of 'rab' on soils	14

C

Cachar, botanical collections from	132
<i>Calamus</i> , monograph of the genus	139
Calcutta, estuarine beds at	73
Camphor, Ngai, distillation of	37
<i>Canarium</i> , resin of	17
Cape Copper Company in the Matigara mine, work by	79, 80
Carbonic acid in soil	13
<i>Carica Papaya</i> , papain from	28
<i>Caryophyllaceae</i> of Tibet	132

	Page.
<i>Cassiterite</i> in Mergui	98
Catechu, reports on	28
<i>Catenella impudica</i> , chemistry of	25
Cattle foods	29
<i>Cecidomyia</i> , sp., teak gall	193
Central India, canal heads in	81
" " , Geological Survey in	103
Central Provinces, Geological Survey in	108
" " , gondite series in	62
" " , manganese in	85
<i>Cerlops Roxburghiana</i> , fuel of	11
Charas, estimation of	27
Checking traverse work	117
<i>Chermes abietis-piceæ</i> ,—life history of	191
" <i>himalayensis</i> , " " 	191, 194
" <i>viridis</i> , " " 	194
Chilgoza pine, insect pests of	193
China clay, occurrence of	77
Chhindwara, manganese in	85
Chindwin, Lower, petroleum in	88
Chir pine, insect pest of the	193
<i>Chloroxylon Swietenia</i> , pests of	193
Chota Nagpur, iron-ore in	83
<i>Chromite</i> in Singbhum	77
Civil Veterinary Department Programme for 1909-10	224
Clarification of Indian colophony	39
" of tannin liquors	35
<i>Cælopoceras</i> , collection of	66
<i>Cælosterna scabrata</i> , a pest on <i>Acacia</i>	193
Coffee, analyses of	25
Coimbatore, flora of	136
Colleges, Indian Zoological research in	175
Coniferous pests	191—193
Copper in Singbhum	78
Copper-ores, assays of	80
Cotton, hybridisation experiments in Indian	147
" natural cross-fertilisation in Indian	147
" seed oil	18
Crop insect pests	185
Crops of the Bombay Presidency	149
" , water required by	12
<i>Curcuma</i> starch	24
'Cutch' or catechu, chemistry of	28
Cutch, flora of the district of	134

D

<i>Dalbergia Sissoo</i> , yield tables of	167
Dalma trap, Singbhum	62
Dandot Colliery, pyritous shale of	77
<i>Datura</i> , alkaloids of	229
Deccan Trap in Rajputana	107
Decolorization of colophony	39
„ of Mangrove bark	35
„ of Sâl bark	36
Dehra Dun, magnetic observatory at	55
Delhi series of rocks, Geological Survey of	105
<i>Dendrophyllia</i> , description of	73
Deodar forest, insect pests of	189, 190
Dhalbhum, copper in	86
Dharwars in Chanda, Geological Survey of	108
<i>Dioscorea</i> , new sp. of	140
Diptera, investigations of	173, 187
<i>Dipterocarpus</i> , resins of	17
Dung, cow, value as fuel	10
Dyes, chemistry of	19—22

E

Eau-de-Cologne, country-made	27
Economic enquiries, geological	75
<i>Elæodendron</i> , gum of	17
<i>Eleusine coracana</i> , chemistry of	24
Elateryd grubs, a pest of deodar	192
<i>Eudesia</i> sp., occurrence of	70, 71
Engineering questions on geological features	81
Entomology in the Indian Museum	173
<i>Eremurus</i> , glue from	17
Eri-silk	186
Estuarine beds, Calcutta	73
Evershed spectroscopie	43
Extracts, mangrove tannin	35
„, Sâl tannin	36
„, trials of mixed tannin	36

F

Fauna of British India	176
Ferns of Mussoorie	139
Flora of the Bombay Presidency	133

	Page.
Fibre investigations in India	148
<i>Ficus elastica</i> , rubber of	18
Firaiman, <i>Orbitolina</i> from	63
Fireclay, Rajmahal	82
Fish, collecting of Indian	174
Fish, fossil from Lameta beds	74
Fishery investigations	174
Fish-liver oils	19
Fish manure	30
Flocculi (see article on Astronomy)	43
Flora of Baluchistan	137
„ of Coimbatore	136
„ of Cutch	134
„ of the Malayan Peninsula	139
„ of N.-W India, Key to the	137
„ of the Presidency of Bombay	133
„ of the Upper Gangetic Plain	137
„ of Travancore	135
Forest College, Educational work at	153
„ Department Programme for 1909-10	218
„ oil seeds	171
„ publications, list of	42, 167, 172, 194
Fossil fish, Lameta beds	74
Fossils in Vindhyan shales	106
Freshwater Fauna of India	175
„ fossils in Pegu beds	73
Fruit flies	187
Fuel, calorific power of Indian woods	39
<i>Furcræa</i> fibre	23

G

Galena in Mergui	98
Gangetic Plain, flora of the	137
Gangpur State, manganese in	85
Garividi, Vizagapatam, <i>Vredenburgite</i> at	60
Geodetic base at Dehra Dun, construction of	116
Geological disturbances in Mergui	97
„ Survey Department Programme for 1909-10	209
Ghi, adulteration of	19
Glass-making sands in Rajmahal	82
Glucosides in cattle foods	29
Golabgarh Pass, Kashmir Section in the	110
Gold in Mergui	98
Gondite Series, Central Provinces	62

	Page.
Gondwana plants, Pench Valley	74
Gondwanas in Kashmir	110
Granites in Mergui	95
Granophyres in Singbhum	61
Grasses, study of forest	156
Grating, Thorpe	47
<i>Grewias</i> , study of	157
Gwegyo Hills, survey of	89
<i>Gynandropis pentaphylla</i> , oil of	18
Gypsum in Hamirpur	83

H

<i>Hæmorrhagic Septicæmia</i> —Serum and vaccine methods of inoculation	196
Hakigora, iron ore of	84
Hamirpur, gypsum in	83
<i>Hardwickia binata</i> , notes on	166
Hemp drug, estimation of	27
Herbarium of the Imperial Forest Research Institute	153, 159
<i>Hibiscus Sabdariffa</i> , dye from	22
Hides, loading of	22
Himalayas, botanical exploration of the Eastern	131
Himalayan trees, study of	166
Hindu River, Tavoy, Tin mining on	99
<i>Hopea</i> , resin of	17
<i>Hoplocerambyx spinicornis</i> , insect pest	190
<i>Hyoscyamus</i> , alkaloids of	229

I

Ichthyological research	174
<i>Idiocerus Atkinsonii</i> , mango pest	193
„ <i>clypeatis</i> , „ „	193
„ <i>niveolus</i> , „ „	193
Immune wheats	146
Imperial Institute Programme for 1909-10	205
Indian Museum, research in	173
Indian Standard Bar	122
Indigo, analysis of	19
„ conditions under which plant forms dye	20
„ dying tests with	21
„ manufacture	21
„ manuring of	15
„ seet water	21
<i>Ingura subapicalis</i> , defoliator	189

	Page.
Insecticides	186
Insect pests of crops	185
International Union of Solar Research	47
Intertrappean beds in Rajputana	107
Invar wire	116
"Investigator," R. I. M. S., work on zoological collections of	175
Iron in Mergui	98
" ore in Chota Nagpur	83
" ores in Chanda, Central Provinces	109
<i>Ischænum</i> , cellulose of	23

J

Jaba, petroleum of	92
Jassid insect pest	193
Jhalawan, Liassic fossils of	69
<i>Juddite</i> , a new mineral	61
Juniper insect pest	193
Jute races in India	148

K

Kacharwahi, Nagpur, <i>Juddite</i> at	61
Kalabagh, alum of	75
Kaolin, occurrence of, in Rajmahal	77
Kara-nor lake, geography of the	112
Karikal, fossils of	64
Kashmir, botanical collections from	138
Kashmir, Geological Survey in	109
" <i>Orbitolina</i> from	63
Keri or lac refuse	17
Keriya river	112
Kodaikanal, Magnetic Observatory at	54
Kotki, alum shales at	75, 76
Kuen Lun Range, geographical exploration of the	113

L

Lac, analysis of	17, 40
" , cultivation of	186
Lacquer Burmese, chemistry of	17, 18
Lac resin, analytical constants and effect of melting on	41
Lameta beds	74, 107
" " fossil fish of	74
Las Bela, Liassic fossils of	69

	Page.
Lasiocampid defoliator	189
Laterite in Central India	107
„ in Mergui	97
Latitude, tables of	120
Lankisra boring	80
Lead-ore in Mergui	98
Leda Hill, manganese at	85
Levelling operations	122
Liassic fossils of Baluchistan	69
'Ligno,' as a specific against wood splitting	170
Linseed, glucosides of	29
Lithomarge in Mergui	97
<i>Litsæa seylanica</i> , oil of	18
Littrow spectroheliograph	44
Longicorn wood borer	193
Longitude, tables of	120
<i>Lotus arabicus</i> as a cattle food	29
<i>Lymantria</i> defoliator	189

M

Manganese rocks of Singbhum	85
Magnetic constants for 1908	55
<i>Magnetite</i> in black soils	14
Malayan Peninsula, flora of the	139
Manganese deposits	84
„ „ minerals, new	60
„ „ ores, age of	85
Mangoes from Bhagalpur	149
Mango, peori dye from	22
„ insect pests	193
Manna, Tamarisk	24
Manure, fish	30
Manures, green	15
Marine Tertiaries, Peninsular Coast	63
Marine Zoology, work on Indian	175
Match industry	171
„ woods, bleaching of coloured	38
Matigara, Dhalbhum, copper at	80
Maungmeshang, Tavoy, tin mining at	98
Medical Zoology	176
<i>Melanorrhæa</i> , varnish of	17
<i>Melipona</i> (bees), resin of nests of	17
Melolonthid grubs	192
Memoirs of the Indian Meteorological Department	54

	Page.
Mergui Archipelago, Geology of	95
„ series of rocks	96
Meteorological Department Programme for 1909-10	207
Mianwali District, alum of	75
Michelson grating	44
Mineralogy	60
Mines in Central Provinces, inspection of	85
<i>Moringa pterygosperma</i> , oil of	18
Mosses from the Western Ghats	135
Moulmein group of rocks	97
Mourbhanj, fossils from	64
Mulberry disease	152
„ silk	186
Myrobalans	22

N

Nagpur, manganese in	86
Natrani river, Baluchistan, Liassic fossils of	69
Neocomian fossils of Baluchistan	69
Nepal, botanical tour in, by I. H. Burkill	131
Ngai camphor	28, 37
Northern Baluchistan, Geodetic Survey in	118
<i>Nummulites planulatus</i>	67
„ <i>Vredenburgi</i>	68

O

Oaks, insect pests of Himalayan	193
Oil-fields, Upper Burma	87
Oil-seeds from forest trees	37, 171
Onbingwin, Tavoy, tin mining at	99
Opium, chemistry of	28
<i>Orbitolina</i>	63
Orchids of the Bombay Presidency	135

P

Pachbadra, salt observations at	93
Pakokku, prospects of oil in	88
Papain	28
Paper stuff	170
Parabolic grating	43
Parasites and parasitic diseases (veterinary)	198
Payagyigon-Ngashandaung oil-field	89, 90

	Page.
Pegu beds, Yenangyaung	73
Pench Valley, Gondwana plants of	74
Pendulum operations	123
Peori dye	22
Petroleum	87
Petrology	61
<i>Phaseolus lunatus</i> as a cattle food	29
<i>Phlasinus Zhobi</i> , bark borer	193
Photoheliograph	44
<i>Phragmites Karka</i> , cellulose of	23
<i>Picea Morinda</i> , study of	166
<i>Pinus longifolia</i> , shoot borer in	193
<i>Piroplasma bovis</i>	198
Pir Panjal Range, Gondwana beds in	110
<i>Petyogenes conifera</i> , insect pest	192
<i>Placenticeræ</i>	65
Plantain meal	24
<i>Plantanista gangetica</i> , liver oil of	19
Plantation work, agri-sylvicultural	167
Plants, Gondwana	74
Pollination, studies in	141
<i>Polygraphus</i> , bark-borers	192
Polyzoa, fresh water	175
Poona, Takhtasingji observatory at	47
Popa Volcano, Geological Survey of	88
Post-Tertiary deposits, Bugti Hills	102
Potatoes in the Central Provinces	150
Potential Gradient (electrical)	53
Principal Triangulation	118
<i>Pristis perottetis</i> , liver oil of	19
Proceedings of the Board, Summary of 15th—17th Meetings	3
Prominences, solar	43
<i>Prunus eburnea</i> , gum from	17
" " seed as a substitute for almond oil	171
<i>Pterocarpus dalbergioides</i>	166
Publications, Agricultural	150
" Botanical	141
" Chemical	30, 42
" Entomological	188, 194
" Forest Department	163, 167, 172
" Meteorological	54
" Zoological	176
" Mycological	152
" Veterinary Science	199
Pulp, wood and bamboo	170

Panjab, oil fields in the	Page.
Pyrheliometers	92
	47

Q

Quartzites, Vindhyan	105, 106
Quartz porphyries in Mergui	96
Quasi-organic remains in Delhi series	105
Quinine, greater yield of	28

R

" Rab " experiments, in the increase of crops	14
Radiation, solar	47
Ragi, chemistry of	24
Rain, electricity of	50
Rajdoha Copper Company	79
Rajmahal Hills, China clay of	77
" " fire clay in	62
" " glass making sands in	82
Rajputana, Geological Survey in	103
" salt in	92
<i>Ramphobates ancylostomus</i> , liver oil	19
Ranikot series, molluscan fauna of	66
Recent deposits in Mergui	97
Reflector, equatorial	47
Refractor, "	47
Reporter on Economic Products Department Programme for 1909-10	205
Resin, clarification of Indian pine	39
Resin lac, analytical constants of	41
Rats, work on Indian	174
Rice, chemistry of	24
<i>Ricinus communis</i> , oil from	18
Root parasitism in Southern India	140, 149, 161
Rubber analyses	18
Rubber-yielding trees introduced into India	150
<i>Rumex hymenosepalus</i> , tannin of	22

S

Sail	188
" insect pests	190, 191
Salt, analysis of	11
Salt in Rajputana	92
<i>Salvadora oleoides</i> , oil of	18

	Page.
Sands, glass-making	82
Sarawan, Liassic fossils of	69
Satpura Hills, discussion of gravity at	124
Scale insects on coffee	187
<i>Schleichera trijuga</i> , oil expressed from the seed of	171
Seasoning of timber	170
Secondary triangulation	121
Seeds, oil of forest	37, 171
<i>Sesamum indicum</i> , oil of	18
Shellac, analytical constants of	41
„ effect of melting on	41
„ from block lac, non-condensable resins in	40—41
„ preparation of	39
Shirinab Valley, Baluchistan, Liassic fossils from	69
<i>Shorea robusta</i> , silviculture of	165
<i>Sida</i> fibre	149
Siderostat, Foucault	42
Silver fir and spruce, wood pulp from	170
Singhbhum, chromite in	77
„ copper in	78
„ granophyres in	61
„ manganese in	85
Singu oil-field, Geological Survey of	89
<i>Sinoxylon anale</i> wood-borer	193
„ <i>crassum</i> wood-borer	193
<i>Sitaparite</i>	60
Siwalik fossils, Bugti Hills	101, 102
Soil, analysis	12
„ carbonic acid in	13
„ movement of water in	12
„ alkali	12
„ black cotton, nature of	14
Soils, drainage waters in analysis of	16
„ moisture in	12
Solar constant	45
„ Physics	42
„ Physics Committee	44
„ radiation	47
Spectra, solar and sunspot	42—45
Spectrograph	43
Spectroheliograph	42
„ , Littrow	44
Spectroscopic investigations (solar)	45
Spessartite-quartz rocks	63
<i>Sphærotrypes</i> , species of	190

	Page.
Splitting tests of Indian timbers	169
Sponges, fresh-water	173
<i>Spiriferina rostrata</i>	71
Starch, manufacture of, from <i>Curcuma</i>	24
<i>Stegostoma tigrinum</i> , liver oil of	19
<i>Starculia fatida</i> , oil of	18
Strength tests of Indian timbers	169
<i>Streptotrichosis</i> ,—cattle lymphangitis or Calcutta sore	198
Sugar, chemistry of	24
Sugarcane, analysis of	24
" manuring of	15
Sulphuric acid	11
Sunspots, pressure in	46
" radial motion in	46
Surgeon-Naturalist, Indian Marine Survey, work of	175
Surra, curative treatment of	197
" in camels	197
" , method of spreading	196
Survey of India Department Programme for 1909-10	209
Sylviculture, investigations in	164

T

Takhtasingji Observatory	47
Takla Makan desert	112
Tamarisk manna	24
Tannin extracts from mangrove and sâl bark	35, 36
Tans and dyes, chemistry of	19-22
Tarim basin	111
Tasar silk	186
Taungtha Hills, Geological Survey of	89
Tavoy, tin mining in	98-100
Teaching, entomological	187
Tea, cheesy flavour of	25
" chemical process in manufacturing	25
" experiments in Assam	15
" green manuring of	15
" lowering of quality by manuring	15
" pests	187
" tannin and alkaloids in	25
Teak in Burma	166
" branch gall	193
" coppice and reproduction of	155
Temperature, proposed standard for Indian laboratories	10
<i>Tephrosia purpurea</i> , dye of	21
<i>Terminalia Arjuna</i> bark for tanning	171

	Page.
Terrestrial magnetism	54
Tertiaries, marine, Peninsular coast	63
Tertiary of Upper Burma	72
" strata, Tavoy	101
Tetanus, investigations of	198
<i>Thespesia Lampas</i> , dye from	22
Thorpe transmission grating	47
Thunderstorms,—theory of	51
Tian Shan Range	112
Tidal operations	121
Timber, powellizing	170
Timbers, Indian, splitting tests of	169
" " seasoning of	170
" " strength tests of	169
Tin, occurrence of	95
<i>Tomicus Ribbentropi</i> , insect pest of blue pine	192
Toungoo, magnetic observatory at	54—55
Toxic action of roots	14
<i>Trabala Vishnu</i> , defoliator	189
Trias, lower, in Kashmir	110
Transpiration of plants	13
<i>Trapa bispinosa</i> , chemistry of nuts of	25
Travancore, forest flora of	135
<i>Trigon microps</i> , liver oil of	19
<i>Trinophylum cribratum</i> , beetle	189
Turamdile, iron ore of	83, 84
Turpentine	229
Tutuguta, Chaibasa, manganese at	85
<i>Twingonia</i> , fossil	73
Twinza reserves, committee on	90

U

United Provinces, canal heads in	81
--	----

V

<i>Vateria</i> , resin of	17
Vertebrate remains, Bugti Hills	102
Vertical pressure differences, atmospheric	53
Vindhya Hills, discussion of gravitation at	124
Vindhyan rocks, lower, in Rajputana	106
" shales, fossils in	106
Volcano of Mount Popa	88
<i>Vredenburgite</i> , mineral	60

W

Wagon, Tavoy, tin mining at	100
Water, movement in soils of	12
" required by crops	12
" salts in irrigating	16
Waxes, sealing, chemistry of	18
Weevil in wheat	186
Wheat, milling and baking qualities of	146
Wheats, chemistry of	23
Wheat, varietal characters of	146
" varieties in Central Provinces	146
Winds of India	53
<i>Wolfram</i> in Tavoy	99
Wood pulp, industry of	170
Woods, antiseptic treatment of	170
" calorific power of, Indian	39

Y

Yenangyaung, geology of	87
" Pegu beds of	73
Yield tables in forestry work	167
Yurungkash river	113

Z

Zewan beds in Kashmir	110
Zoological Department Programme for 1909-10	224
Zoology, Indian, bibliography of	176

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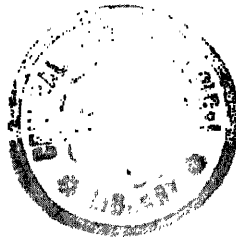
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